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# Ansible Configuration Management

## *Second Edition*

Leverage the power of Ansible to manage your infrastructure efficiently

Daniel Hall

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**Daniel Hall**



BIRMINGHAM - MUMBAI

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I would like to thank my partner, Eliza, for her continued support while writing this book. I would also like to thank my reviewers for their insightful corrections. Finally, I would like to thank everybody at Packt for giving me this opportunity to follow up on the first edition of my book.

---

# About the Reviewers

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Patrik is also a technical reviewer of Learning Ansible and the author of the Zabbix cookbook. Both the books are published by Packt Publishing.

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# Preface

Since CFEngine was first created by Mark Burgess in 1993, configuration management tools have been constantly evolving. Followed by the emergence of more modern tools such as Puppet and Chef, there are now a large number of choices available to a system administrator.

Ansible is one of the newer tools to arrive into the configuration management space. Where other tools have focused on completeness and configurability, Ansible has bucked the trend and, instead, focused on simplicity and ease of use.

In this book, we aim to show you how to use Ansible from the humble beginnings of its CLI tool, to writing playbooks, and then managing large and complex environments. Finally, we teach you how to build your own modules and extend Ansible by writing plugins that add new features.

## What this book covers

*Chapter 1, Getting Started with Ansible*, teaches you the basics of Ansible, how to install it on Windows and Linux, how to build an inventory, how to use modules, and, most importantly, how to get help.

*Chapter 2, Simple Playbooks*, teaches you how to combine multiple modules to create Ansible playbooks to manage your hosts, it also covers a few useful modules.

*Chapter 3, Advanced Playbooks*, delves deeper into Ansible's scripting language and teaches you more complex language constructs; here we also explain how to debug playbooks.

*Chapter 4, Larger Projects*, teaches you the techniques to scale Ansible's configurations to large deployments using many complicated systems, including how to manage various secrets you may use to provision your systems.

*Chapter 5, Custom Modules*, teaches you how to expand Ansible beyond its current capabilities by writing both modules and plugins.

## What you need for this book

To use this book, you will need at least the following:

- A text editor
- A machine with the Linux operating system
- Python 2.6.x or Python 2.7.x

However, to use Ansible to its full effect, you should have several Linux machines available to be managed. You can use a virtualization platform to simulate many hosts, if required. To use the Windows modules, you will need both a Windows machine to be managed and a Linux machine to be the controller.

## Who this book is for

This book is intended for people who want to understand the basics of how Ansible works. It is expected that you have rudimentary knowledge of how to set up and configure Linux machines. In parts of the book, we cover the configuration files of BIND, MySQL, and other Linux daemons; a working knowledge of these would be helpful, but is certainly not required.

## Conventions

In this book, you will find a number of styles of text that distinguish among different kinds of information. Here are some examples of these styles, and an explanation of their meaning.

Code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles are shown as follows: "This is done in a similar way using the `vars_files` directive."

A block of code is set as follows:

```
[group]
machine1
machine2
machine3
```

When we wish to draw your attention to a particular part of a code block, the relevant lines or items are set in bold:


```
tasks:
- name: install apache
  action: yum name=httpd state=installed


- name: configure apache
  copy: src=files/httpd.conf dest=/etc/httpd/conf/httpd.conf
```

Any command-line input or output is written as follows:

```
ansible machinename -u root -k -m ping
```

**New terms** and **important words** are shown in bold. Words that you see on the screen, in menus or dialog boxes for example, appear in the text like this: "clicking the **Next** button moves you to the next screen".

[  Warnings or important notes appear in a box like this. ]

[  Tips and tricks appear like this. ]

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# 1

## Getting Started with Ansible

**Ansible** is profoundly different from other configuration management tools available today. It has been designed to make configuration easy in almost every way, from its simple English configuration syntax to its ease of setup. You'll find that Ansible allows you to stop writing custom configuration and deployment scripts and lets you simply get on with your job.

Ansible only needs to be installed on the machines that you use to manage your infrastructure. It does not need a client to be installed on the managed machine, nor does it need any server infrastructure to be set up before you can use it. You should even be able to use it merely minutes after it is installed, as we will show you in this chapter.

The following are the topics covered in this chapter:

- Installing Ansible
- Configuring Ansible
- Using Ansible from the command line
- Using Ansible to manage Windows machines
- How to get help

### Hardware and software required

You will be using Ansible from the command line on one machine, which we will call the **controller machine**, and use it to configure another machine, which we will call the **managed machine**. Ansible currently only supports a Linux or OS X controller machine; however, the managed machine can be Linux, OS X, other Unix-like machines or Windows. Ansible does not place many requirements on the controller machine and even less on the managed machine.

The requirements for the controller machine are as follows:

- Python 2.6 or higher
- paramiko
- PyYAML
- Jinja2
- httplib2
- Unix-based OS

The managed machine needs Python 2.4 or higher and simplejson; however, if your Python is 2.5 or higher, you only need Python. Managed Windows machines will need Windows remoting turned on, and a version of Windows PowerShell greater than 3.0. While Windows machines do have more requirements, all the tools are freely available and the Ansible project even includes the script to help you easily set up the dependencies.

## Installation methods

If you want to use Ansible to manage a set of existing machines or infrastructure, you will likely want to use whatever package manager is included on those systems. This means that you will get updates for Ansible as your distribution updates it, which may lag several versions behind other methods. However, it means that you will be running a version that has been tested to work on the system you are using.

If you run an existing infrastructure, but need a newer version of Ansible, you can install Ansible via pip. **Pip** is a tool used to manage packages of Python software and libraries. Ansible releases are pushed to pip as soon as they are released, so if you are up to date with pip, you should always be running the latest version.

If you imagine yourself developing lots of modules and possibly contributing back to Ansible, you should be running a version installed from source code. As you will be running the latest and least-tested version of Ansible, you may experience a hiccup or two.

## Installing from your distribution

Most modern distributions include a package manager that automatically manages package dependencies and updates for you. This makes installing Ansible via your package manager by far the easiest way to get started with Ansible; usually it takes only a single command. It will also be updated as you update your machine, though it may be a version or two behind. The following are the commands to install Ansible on the most common distributions. If you are using something different, refer to the user guide of your package or your distribution's package lists:

- Fedora, RHEL, CentOS, and compatible:  
`$ yum install ansible`
- Ubuntu, Debian, and compatible:  
`$ apt-get install ansible`



Note that RHEL and CentOS require the EPEL repository to be installed. Details on EPEL, including how to install it can be found at <https://fedoraproject.org/wiki/EPEL>.

If you are on Ubuntu and wish to use the latest release instead of the one provided by your operating system, you can use the Ubuntu PPA provided by Ansible. Details on setting this up can be found at <https://launchpad.net/~ansible/+archive/ubuntu/ansible>.

## Installing from pip

Pip, like a distribution's package manager, will handle finding, installing, and updating the packages you ask for and its dependencies. This makes installing Ansible via pip as easy as installing from your package manager. It should be noted, however, that it will not be updated with your operating system. Additionally, updating your operating system may break your Ansible installation; however, this is unlikely. If you are a Python user, you might want to install Ansible in an isolated environment (virtual environment): This is not supported as Ansible tries to install its modules to the system. You should install Ansible system-wide using pip.

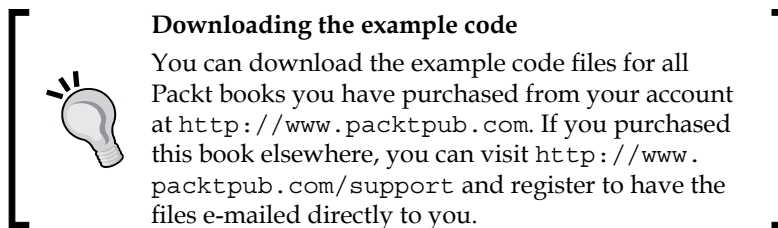
The following is the command to install Ansible via pip:

```
$ pip install ansible
```

## Installing from the source code

Installing from the source code is a great way to get the latest version, but it may not be tested as correctly as the released versions. You also will need to take care of updating to newer versions yourself and making sure that Ansible will continue to work with your operating system updates. To clone the `git` repository and install it, run the following commands. You may need root access to your system to do this:

```
$ git clone git://github.com/ansible/ansible.git
$ cd ansible
$ sudo make install
```



## Setting up Ansible

Ansible needs to be able to get an inventory of the machines that you want to configure in order to manage them. This can be done in many ways due to inventory plug-ins. Several different inventory plug-ins are included with the base install. We will go over these later in the book. For now, we will cover the simple host's file inventory.

The default Ansible inventory file is named `hosts` and is placed at `/etc/ansible`. It is formatted like an `INI` file. Group names are enclosed in square braces, and everything underneath it, down to the next group heading, gets assigned to that group. Machines can be in many groups at one time. Groups are used to allow you to configure many machines at once. You can use a group instead of a hostname as a host pattern in later examples, and Ansible will run the module on the entire group at once.

In the following example, we have three machines in a group named `webservers`, namely `site01`, `site02`, and `site01-dr`. We also have a `production` group that consists of `site01`, `site02`, `db01`, and `bastion`.

```
[webservers]
site01
site02
site01-dr
```

```
[production]
site01
site02
db01
bastion
```

Once you have placed your hosts in the Ansible inventory, you can start running commands against them. Ansible includes a simple module called `ping` that lets you test connectivity between yourself and the host. Let's use Ansible from the command line against one of our machines to confirm that we can configure them.

Ansible was designed to be simple, and one of the ways the developers have done this is by using SSH to connect to the managed machines. It then sends the code over the SSH connection and executes it. This means that you don't need to have Ansible installed on the managed machine. It also means that Ansible uses the same channels that you are already using to administer the machine. This makes it easier to setup, because in most cases there will be no setup required and no ports to open in a firewall.

First, we check connectivity to our server to be configured using the Ansible `ping` module. This module simply connects to the following server:

```
$ ansible site01 -u root -k -m ping
```

This should ask for the SSH password and then produce a result that looks like the following:

```
site01 | success >> {
  "changed": false,
  "ping": "pong"
}
```

If you have an SSH key set up for the remote system, you will be able to leave off the `-k` argument to skip the prompt and use the keys. You can also configure Ansible to use a particular username all the time by either configuring it in the inventory on a per host basis or in the global Ansible configuration.

To set the username globally, edit `/etc/ansible/ansible.cfg` and change the line that sets `remote_user` in the `[defaults]` section. You can also change `remote_port` to change the default port that Ansible will SSH to. This will change the default settings for all the machines, but they can be overridden in the inventory file on a per server or per group basis.

To set the username in the inventory file, simply append `ansible_ssh_user` to the line in the inventory. For example, the following code section shows an inventory where the `site01` host uses the username `root` and the `site02` host uses the username `daniel`. There are also other variables you can use. The `ansible_ssh_host` variable allows you to set a different hostname, and the `ansible_ssh_port` variable allows you to set a different port, which is demonstrated on the `site01-dr` host. Finally the `db01` host uses the username `fred` and also sets a private key using `ansible_ssh_private_key_file`.

```
[webservers]          #1
site01 ansible_ssh_user=root          #2
site02 ansible_ssh_user=daniel        #3
site01-dr ansible_ssh_host=site01.dr ansible_ssh_port=65422      #4
[production]         #5
site01                #6
site02                #7
db01 ansible_ssh_user=fred
ansible_ssh_private_key_file=/home/fred/.ssh.id_rsa              #8
bastion               #9
```

If you aren't comfortable with giving Ansible direct access to the root account on the managed machines, or your machine does not allow SSH access to the root account (such as Ubuntu's default configuration), you can configure Ansible to obtain root access using `sudo`. Using Ansible with `sudo` means that you can enforce auditing the same way you would otherwise. Configuring Ansible to use `sudo` is as simple as it is to configure the port, except that it requires `sudo` to be configured on the managed machine.

The first step is to add a line to the `/etc/sudoers` file; on the managed node, this may already be set up if you choose to use your own account. You can use a password with `sudo`, or you can use a passwordless `sudo`. If you decide to use a password, you will need to use the `-k` argument to Ansible, or set the `ask_sudo_pass` value to `true` in `/etc/ansible/ansible.cfg`. To make Ansible use `sudo`, add `--sudo` to the command line like this:

```
ansible site01 -s -m command -a 'id -a'
```

If this works, it should return something similar to:

```
site01 | success | rc=0 >>
uid=0(root) gid=0(root) groups=0(root)
context=unconfined_u:unconfined_r:unconfined_t:s0-s0:c0.c1023
```

## Setting it up on Windows

Ansible recently added the ability to manage Windows machines. Now, you can use Ansible to easily manage Windows machines the same way you manage your Linux machines.

This uses the Windows PowerShell Remoting tools in the same way that SSH is used on a Linux machine to execute modules remotely. Several new modules have been added that explicitly support Windows, but some existing modules have also been given the ability to work with Windows-managed machines.

To get started with managing your Windows machine, you do have to perform a little bit of complex setup. You need to follow these steps:

1. Create some Windows machines in your inventory
2. Install Python-winrm to allow Ansible to connect to the Windows machines
3. Upgrade to PowerShell 3.0+ to support Windows modules
4. Enable Windows remoting so that Ansible can connect

Windows machines are created the same way as all the other machines that you have in your inventory. They are differentiated by the value of the `ansible_connection` variable. When `ansible_connection` is set to `winrm`, it will try to connect via `winrm` to Windows PowerShell on the remote machine. Ansible also uses the `ansible_ssh_user`, `ansible_ssh_pass`, and `ansible_ssh_port` values like it would on your other machine. Despite having the name `ssh` in them, they are used to provide the port and credentials that will be used to connect to the Windows PowerShell Remoting service. Here is what an example Windows machine might look like:

```
[windows]
dc.ad.example.com
web01.ad.example.com
web02.ad.example.com

[windows:vars]
ansible_connection=winrm
ansible_ssh_user=daniel
ansible_ssh_pass=s3cr3t
ansible_ssh_port=5986
```



For security reasons, you probably will not want to store the password in the inventory file. You can make Ansible prompt for the password the same way we showed previously for Unix systems by simply leaving off the `ansible_ssh_user` and `ansible_ssh_pass` variables and instead using the `-k` and `-u` arguments to Ansible if you wish. You might also choose to store them in an Ansible vault, which will be covered later in the book.

After you have created the inventory, you need to install the `winrm` Python library on the controller machine. This library will give Ansible the ability to connect to the Windows Remote Management service and configure a remote Windows system.

At the moment, this library is fairly experimental, and its connection to Ansible isn't quite perfect, so you have to install the particular version that matches the version of Ansible you are using. With the release of Ansible 1.8, this should sort things out a little bit. Most distributions do not have a packaged library yet, so you will probably want to install it via `pip`. As root, you need to run:

```
$ pip install https://github.com/diyan/pywinrm/archive/df049454a9309280866e0156805ccd12d71c93a.zip
```

However, for newer versions, you should simply be able to run:

```
pip install http://github.com/diyan/pywinrm/archive/master.zip
```

This will install the particular version of `winrm` that works with Ansible 1.7. For other newer versions of Ansible, you may need a different version, and eventually the `winrm` Python library should be packaged up by different distributions. Your machine will now be able to connect to and manage Windows machines with Ansible.

Next you have to perform a few setup steps on the machine you are going to manage. The first of these is to make sure that you have PowerShell 3.0 or later installed. You can check what version you have installed with the following command:

```
$PSVersionTable.PSVersion.Major
```

If the value you get back is not 3 or higher than 3, then you will need to upgrade your version of PowerShell. You can choose to do this manually by downloading and installing the latest Windows Management Framework for your system, or you can use a script provided by the Ansible project. To save space, we will be explaining the scripted installation here; the manual installation is left as an exercise for the reader.

```
Invoke-WebRequest  
https://raw.githubusercontent.com/ansible/ansible/release1.7.0/examples/  
scripts/upgrade_to_ps3.ps1 -OutFile upgrade_to_ps3.ps1  
.\upgrade_to_ps3.ps1
```

The first command downloads the upgrade script from the Ansible project repository on GitHub and saves it to disk. The second command will detect your operating system to download the correct version of the Windows Management Framework and install it.

Next you need to configure the Windows Remote Management Service. The Ansible project provides a script that will configure Windows Remote Management automatically in the way that Ansible expects it to be configured. While you can set it up manually, it is highly recommended that you use this script instead to prevent misconfiguration. To download and run this script, open a PowerShell terminal and run the following commands:

```
Invoke-WebRequest
https://raw.githubusercontent.com/ansible/ansible/release1.7.0/
examples/scripts/ConfigureRemotingForAnsible.ps1 -OutFile
ConfigureRemotingForAnsible.ps1
.\ConfigureRemotingForAnsible.ps1
```

The first command downloads the configuration script from the Ansible project on GitHub, and the second command runs it. You should receive the output `ok` from the second script if everything worked correctly.

You should now be able to connect to your machine and configure it with Ansible. As we did earlier, let's run a `ping` command to confirm that Ansible is able to execute its modules remotely. While Unix machines can use the `ping` module, Windows machines use the `win_ping` module. The usage is almost exactly the same; however, as we've added the password to the inventory file, you don't need the `-k` option.

```
$ ansible web01.ad.example.com -u daniel -m win_ping
```

If everything works correctly, you should see the following output:

```
web01.ad.example.com | success >> {
    "changed": false,
    "ping": "pong"
}
```

The output indicates that Ansible was able to connect to the Windows Remote Management Service, login successfully, and execute a module on the remote host. If this works correctly, then you should be able to use all the other Windows modules to manage your machine.

## First steps with Ansible

Ansible modules take arguments in key-value pairs that look similar to `key=value`, perform a job on the remote server, and return information about the job as JSON. The key-value pairs allow the module to know what to do when requested. They can be hardcoded values, or in playbooks they can use variables, which will be covered in *Chapter 2, Simple Playbooks*. The data returned from the module lets Ansible know if anything changed in the managed host or if any information kept by Ansible should be changed afterwards.

Modules are usually run within playbooks, as this lets you chain many together, but they can also be used on the command line. Previously, we used the `ping` command to check that Ansible had been correctly setup and was able to access the configured node. The `ping` module only checks that the core of Ansible is able to run on the remote machine, but effectively does nothing.

A slightly more useful module is named `setup`. This module connects to the configured node, gathers data about the system, and then returns those values. This isn't particularly handy for us while running from the command line. However, in a playbook, you can use the gathered values later in other modules.

To run Ansible from the command line, you need to pass two things, though usually three. First is a host pattern to match the machine that you want to apply the module to. Second you need to provide the name of the module that you wish to run and optionally any arguments that you wish to give to the module. For the host pattern, you can use a group name, a machine name, a glob, and a tilde (~), followed by a regular expression matching hostnames. Alternatively, to symbolize all of these, you can either use the word `all` or simply `*`. Running Ansible modules on the command line this way is referred to as an ad hoc Ansible command.

To run the `setup` module on one of your nodes, you need the following command line:

```
$ ansible machinename -u root -k -m setup
```

The `setup` module will then connect to the machine and give you a number of useful facts back. All the facts provided by the `setup` module itself are prepended with `ansible_` to differentiate them from variables.

This module will work on both Windows and Unix machines. Currently, Unix machines will give much more information than a Windows machine. However, as new versions of Ansible are released, you can expect to see more Windows functionality get included along with Ansible.

```
machinename | success >> {  
  "ansible_facts": {
```

```

    "ansible_distribution": "Microsoft Windows NT 6.3.9600.0",
    "ansible_distribution_version": "6.3.9600.0",
    "ansible_fqdn": "ansibletest",
    "ansible_hostname": "ANSIBLETEST",
    "ansible_ip_addresses": [
        "100.72.124.51",
        "fe80::1fd:fc3b:1eff:350d"
    ],
    "ansible_os_family": "Windows",
    "ansible_system": "Win32NT",
    "ansible_totalmem": "System.Object[]"
  },
  "changed": false
}

```

The following is a table of the most common values you will use; not all of these will be available on all machines. Windows machines especially return a lot less data from the setup module.

Field	Example	Description
ansible_architecture	x86_64	This is the architecture of the managed machine
ansible_distribution	CentOS	This is the Linux or Unix distribution on the managed machine
ansible_distribution_version	6.3	This is the version of the preceding distribution
ansible_domain	example.com	This is the domain name part of the server's hostname
ansible_fqdn	machinename.example.com	This is the fully qualified domain name of the managed machine
ansible_interfaces	["lo", "eth0"]	This is a list of all the interfaces the machine has, including the loopback interface
ansible_kernel	2.6.32-279.el6.x86_64	This is the kernel version installed on the managed machine
ansible_memtotal_mb	996	This is the total memory in megabytes available on the managed machine
ansible_processor_count	1	These are the total number of CPUs available on the managed machine

Field	Example	Description
ansible_virtualization_role	guest	This determines whether the machine is a guest or a host machine
ansible_virtualization_type	kvm	This is the type of virtualization setup on the managed machine

On a Unix machine, these variables are gathered using Python from the managed machine; if you have `facter` or `ohai` installed on the remote node, the `setup` module will execute them and return their data as well. As with other facts, `ohai` facts are prepended with `ohai_` and `facter` facts with `facter_`. While the `setup` module doesn't appear to be too useful on the command line, it is useful once you start writing playbooks. Note that `facter` and `ohai` are not available in Windows hosts.

If all the modules in Ansible do as little as the `setup` and the `ping` module, we will not be able to change anything on the remote machine. Almost all of the other modules that Ansible provides, such as the `file` module, allow us to actually configure the remote machine.

The `file` module can be called with a single path argument; this will cause it to return information about the file in question. If you give it more arguments, it will try and alter the file's attributes and tell you if it has changed anything. Ansible modules will tell you if they have changed anything, which becomes more important when you are writing playbooks.

You can call the `file` module, as shown in the following command, to see details about `/etc/fstab`:

```
$ ansible machinename -u root -k -m file -a 'path=/etc/fstab'
```

The preceding command should elicit a response like the following:

```
machinename | success >> {
  "changed": false,
  "group": "root",
  "mode": "0644",
  "owner": "root",
  "path": "/etc/fstab",
  "size": 779,
  "state":
  "file"
}
```

Alternatively, the response could be something like the following command to create a new test directory in `/tmp`:

```
$ ansible machinename -u root -k -m file -a 'path=/tmp/
teststate=directory mode=0700 owner=root'
```

The preceding command should return something like the following:

```
machinename | success >> {
  "changed": true,
  "group": "root",
  "mode": "0700",
  "owner": "root",
  "path": "/tmp/test",
  "size": 4096,
  "state": "directory"
}
```

We can see that the `changed` variable is set to `true` in the response, because the directory doesn't exist or has different attributes and changes were required to make it match the state given by the provided arguments. If it is run a second time with the same arguments, the value of `changed` will be set to `false`, which means that the module did not make any changes to the system.

There are several modules that accept similar arguments to the `file` module, and one such example is the `copy` module. The `copy` module takes a file on the controller machine, copies it to the managed machine, and sets the attributes as required. For example, to copy the `/etc/fstab` file to `/tmp` on the managed machine, you will use the following command:

```
$ ansible machinename -m copy -a 'src=/etc/fstab dest=/tmp/fstab'
```

The preceding command, when run the first time, should return something like the following:

```
machinename | success >> {
  "changed": true,
  "dest": "/tmp/fstab",
  "group": "root",
  "md5sum": "fe9304aa7b683f58609ec7d3ee9eea2f",
  "mode": "0700",
  "owner": "root",
  "size": 637,
}
```

```
"src": "/root/.ansible/tmp/ansible-1374060150.96-77605185106940/source",
  "state": "file"
}
```

There is also a module named `command` that will run any arbitrary command on the managed machine. This lets you configure it with any arbitrary command, such as a preprovided installer or a self-written script; it is also useful for rebooting machines. Note that this module does not run the command within the shell, so you cannot perform redirection, use pipes, expand shell variables, or background commands.

Ansible modules strive to prevent changes being made when they are not required. This is referred to as idempotency and can make running commands against multiple servers much faster. Unfortunately, Ansible cannot know if your command has changed anything or not, so to help it be more idempotent, you have to give it some help. It can do this either via the `creates` or the `removes` argument. If you give a `creates` argument, the command will not run if the filename argument exists. The opposite is true of the `removes` argument; if the filename exists, the command will run.

You can run the command as follows:

```
$ ansible machinename -m command -a 'rm -rf /tmp/testing
removes=/tmp/testing'
```

If there is no file or directory named `/tmp/testing`, the command output will indicate that it was skipped, as follows:

```
machinename | skipped
```

Otherwise, if the file did exist, it will look like the following code:

```
ansibletest | success | rc=0 >>
```

Often it is better to use another module in place of the `command` module. Other modules offer more options and can better capture the problem domain they work in. For example, it would be much less work for Ansible and also the person writing the configurations to use the `file` module in this instance, since the `file` module will recursively delete something if the state is set to `absent`. So the preceding command would be equivalent to the following command:

```
$ ansible machinename -m file -a 'path=/tmp/testing state=absent'
```

If you need to use features usually available in a shell while running your command, you will need the `shell` module. This way you can use redirection, pipes, or job back grounding. You can pick which shell to use with the `executable` argument. You can use the `shell` module as follows:

```
$ ansible machinename -m shell -a '/opt/fancyapp/bin/installer.sh >/var/log/fancyappinstall.log creates=/var/log/fancyappinstall.log'
```

## Module help

Unfortunately, we don't have enough space to cover every module that is available in Ansible; luckily though, Ansible includes a command name `ansible-doc` that can retrieve help information. All the modules included within Ansible have this data populated; however, with modules gathered from elsewhere you may find less help. The `ansible-doc` command also allows you to see a list of all modules available to you.

To get a list of all the modules that are available to you along with a short description of each type, use the following command:

```
$ ansible-doc -l
```

To see the help file for a particular module, you supply it as the single argument to `ansible-doc`. To see the help information for the `file` module, for example, use the following command:

```
$ ansible-doc file
```

## Summary

In this chapter, we have covered which installation type to choose for installing Ansible and how to build an inventory file to reflect your environment. After this we saw how to use Ansible modules in an ad hoc style for simple tasks. Finally we discussed how to learn which modules are available on your system and how to use the command line to get instructions for using a module.

In the next chapter, you will learn how to use many modules together in a playbook. This allows you to perform more complex tasks than you could do with single modules alone.





# 2

## Simple Playbooks

Ansible can be used as a command-line tool for making small changes. However, its real power lies in its scripting abilities. While setting up machines, we almost always need to do more than one thing at a time. Ansible uses a concept named **playbook** to do this. Using playbooks, we can perform many actions at once, and across multiple systems. They provide a way to orchestrate deployments, ensure a consistent configuration, or simply perform a common task.

Playbooks are expressed in **YAML**, and for the most part, Ansible uses a standard YAML parser. This means that we have all the features of YAML available to us as we write them. For example, we can use the same commenting system in playbook as we would in YAML. Many lines of a playbook can also be written and represented in YAML data types. See <http://www.yaml.org/> for more information.

Playbooks also open up many opportunities. They allow us to carry the state from one command to the other. For example, we can grab the content of a file on one machine, register it as a variable, and then use the value on another machine. This allows us to make complex deployment mechanisms that will be impossible with the Ansible command alone. Additionally, since each module tries to be idempotent, we should be able to run a playbook several times and changes will only be made if they need to be.

The command to execute a playbook is `ansible-playbook`. It accepts arguments similar to the Ansible command-line tool. For example, `-k` (`--ask-pass`) and `-K` (`--ask-sudo`) make Ansible prompt for the SSH and sudo passwords, respectively; `-u` can be used to set the user to use for SSH. However, these options can also be set inside the playbooks themselves in the target section. For example, to use the play named `example-play.yml`, we can use the following command:

```
$ ansible-playbook example-play.yml
```

The Ansible playbooks are made up of one or more plays. A play consists of three sections:

- The **target section** defines the hosts on which the play will be run, and how it will be run. This is where we set the SSH username and other SSH-related settings.
- The **variable section** defines variables, which will be made available to the play while running.
- The **task section** lists all the modules in the order we want them to be run by Ansible.

We can include as many plays as we want in a single YAML file. YAML files start with `---` and contain many key values and lists. In YAML line indentation is used to indicate variable nesting to the parser, which also makes the file easier to read.

A full example of an Ansible play looks like the following code snippet:

```
---
- hosts: webserver
  user: root
  vars:
    apache_version: 2.6
    motd_warning: 'WARNING: Use by ACME Employees ONLY'
    testserver: yes
  tasks:
    - name: setup a MOTD
      copy:
        dest: /etc/motd
        content: "{{ motd_warning }}"
```

In the next few sections, we will examine each section and explain in detail how they work.

## The target section

The target section looks like the following code snippet:

```
- hosts: webserver
  user: root
```

This is an incredibly simple version, but likely to be all we need in most cases. Each play exists within a list. As per the YAML syntax, the line must start with a dash. The hosts that a play will be run on must be set in the value of `hosts`. This value uses the same syntax as the one used when selecting hosts using the Ansible command line, which we discussed in the previous chapter. The host-pattern-matching features of Ansible were also discussed in the previous chapter. In the next line, the user tells the Ansible playbook which user to connect to the machine as.

The other lines that we can provide in this section are as follows:

Name	Description
<code>sudo</code>	Set this to <code>yes</code> if you want Ansible to use <code>sudo</code> to become the root once it is connected to the machines in the play.
<code>user</code>	This defines the username to connect to the machine originally, before running <code>sudo</code> if configured.
<code>sudo_user</code>	This is the user that Ansible will try and become using <code>sudo</code> . For example, if we set <code>sudo</code> to <code>yes</code> and <code>user</code> to <code>daniel</code> , setting <code>sudo_user</code> to <code>kate</code> will cause Ansible to use <code>sudo</code> to get from <code>daniel</code> to <code>kate</code> once logged in. If you were doing this in an interactive SSH session, we could use <code>sudo -u kate</code> while you are logged in as <code>daniel</code> .
<code>connection</code>	This allows us to tell Ansible what transport to use to connect to the remote host. We will mostly use <code>ssh</code> or <code>paramiko</code> for remote hosts. However, we could also use <code>local</code> to avoid a connection overhead when running things on the <code>localhost</code> . Most of the time we will be using either <code>local</code> , <code>winrm</code> or <code>ssh</code> here.
<code>gather_facts</code>	Ansible will automatically run the <code>setup</code> module on the remote hosts unless we tell it not to. If we don't need the variables from the <code>setup</code> module, we could set this now and save some time.

## The variable section

Here, we can define variables that apply to the entire play on all machines. We can also make Ansible prompt for variables if they weren't supplied on the command line. This allows us to make easily maintainable plays, and prevents us from changing the same thing in several parts of the play. This also allows us to have the entire configuration for the play stored at the top, where we can easily read and modify it without worrying about what the rest of the play does.

Variables in this section of a play can be overridden by machine facts (those that are set by modules), but they themselves override the facts we set in our inventory. So they are useful to define defaults that we might collect in a module later, but they can't be used to keep defaults for inventory variables as they will override those defaults.

Variable declarations, which happen in the `vars` section, look like the values in the target section and contain a YAML dictionary or a list. An example looks like the following code snippet:

```
vars:
  apache_version: 2.6
  motd_warning: 'WARNING: Use by ACME Employees ONLY'
  testserver: yes
```

Variables can also be loaded from external YAML files by giving Ansible a list of variable files to load. This is done in a similar way using the `vars_files` directive. Then simply provide the name of another YAML file that contains its own dictionary. This means that instead of storing the variables in the same file, they can be stored and distributed separately, allowing us to share our playbook with others.

Using `vars_files`, the files look like the following code snippet in our playbook:

```
vars_files:
  conf/country-AU.yml
  conf/datacenter-SYD.yml
  conf/cluster-mysql.yml
```

In the previous example, Ansible looks for `country-AU.yml`, `datacenter-SYD.yml`, and `cluster-mysql.yml` in the `conf` folder relative to the playbook path. Each YAML file looks similar to the following code snippet:

```
---
ntp: ntp1.au.example.com
TZ: Australia/Sydney
```

Finally, we can make Ansible ask the user for each variable interactively. This is useful when we have variables that we don't want to make available for automation, and instead require human input. One example where this is useful is when prompting for the passphrases used to decrypt secret keys for the HTTPS servers.

We can instruct Ansible to prompt for variables with the following code snippet:

```
vars_prompt:
  - name: https_passphrase
    prompt: Key Passphrase
    private: yes
```

In the previous example, `https_passphrase` is where the entered data will be stored. The user will be prompted with `Key Passphrase`, and because `private` is set to `yes`, the value will not be printed on the screen as the user enters it.

We can use variables, facts, and inventory variables with the help of `{{ variablename }}`. We can even refer to complex variables, such as dictionaries, with a dotted notation. For example a variable named `httpd`, with a key in it named `maxclients`, will be accessed as `{{ httpd.maxclients }}`. This works with facts from the setup module too. For example, we can get the IPv4 address of a network interface named `eth0` using `{{ ansible_eth0.ipv4.address }}`.

Variables that are set in the variable section do not survive between different plays in the same playbook. However, facts gathered by the setup module or set by `set_fact` do. This means if we are running a second play on the same machines, or a subset of the machines in an earlier play, we can set `gather_facts` in the target section to `false`. The setup module can sometimes take a while to run, so this can dramatically speed up plays, especially in plays where the `serial` is set to a low value.

## The task section

The task section is the last section of each play. It contains a list of actions that we want Ansible to perform in the order we want them to be performed. There are several styles in which we can express each module's arguments. We suggest you try to stick with one as much as possible, and use the others only when required. This makes our playbooks easier to read and maintain. The following code snippet is what a task section looks like with all three styles shown:

```
tasks:
  - name: install apache
    action: yum name=httpd state=installed

  - name: configure apache
    copy: src=files/httpd.conf dest=/etc/httpd/conf/httpd.conf

  - name: restart apache
    service:
      name: httpd
      state: restarted
```

Here we see the three different styles of syntax being used to install, configure, and start the Apache web server as it will look on a CentOS machine. The first task shows us how to install Apache using the original syntax, which requires us to call the module as the first keyword inside an `action` key. The second task copies Apache's configuration file into place using the second style of the task. In this style, use the module name in place of the `action` keyword and its value simply becomes its argument. Finally, the last task, the third style, shows how to use the service module to restart Apache. In this style, we use the module name as the key, as usual, but we supply the arguments as a YAML dictionary. This can come in handy when we are providing a large number of arguments to a single module, or if the module wants the arguments in a complex form, such as the cloud formation module. The latter style is quickly becoming the preferred way of writing playbooks, as an increasing number of modules require complex arguments. In this book, we will be using this style in order to save space for the examples and prevent line wrapping.

Note that names are not required for tasks. However, they make good documentation and allow us to refer to each task later on, if required. This will become useful especially when we come to handlers. The names are also outputted to the console when the playbook is run, so that the user can tell what is happening. If we don't provide a name, Ansible will just use the action line of the task or the handler.



Unlike other configuration management tools, Ansible does not provide a fully featured dependency system. This is a blessing and a curse; with a complete dependency system, we can get to a point where we are never quite sure what changes will be applied to a particular machine. Ansible, however, does guarantee that our changes will be executed in the order they are written. So, if one module depends on another module that is executed before it, simply place one before the other in the playbook.

## The handlers section

The handlers section is syntactically the same as the task section and supports the same format for calling modules. Handlers are called only when the task they were called from, records that something changed during execution. To trigger a handler, add a `notify` key to the task with the value set to the name of the task.

Handlers are run if previously triggered when Ansible has finished running the task list. They are run in the order that they are listed in the handlers section, and even if they are called multiple times in the task section, they will run only once. This is often used to restart daemons after they have been upgraded and configured. The following play demonstrates how we will upgrade an **ISC DHCP (Dynamic Host Configuration Protocol)** server to the latest version, configure it, and set it to start at boot. If this playbook is run on a server where the ISC DHCP daemon is already running the latest version and the config files are not changed, the handler will not be called and DHCP will not be restarted. Consider the following code for example:

```
---
- hosts: dhcp
  tasks:
    - name: update to latest DHCP
      yum
      name: dhcp
      state: latest
      notify: restart dhcp

    - name: copy the DHCP config
      copy:
        src: dhcp/dhcpd.conf
        dest: /etc/dhcp/dhcpd.conf
      notify: restart dhcp

    - name: start DHCP at boot
      service:
        name: dhcpd
        state: started
        enabled: yes

  handlers:
    - name: restart dhcp
      service:
        name: dhcpd
        state: restarted
```



Each handler can only be a single module, but we can notify a list of handlers from a single task. This allows us to trigger many handlers from a single step in the task list. For example, if we have just checked out a newer version of any Django application, we can set a handler to migrate the database, deploy the static files, and restart Apache. We can do this by simply using a YAML list on the notify action. This might look something like the following code snippet:

```
---
- hosts: qroud
  tasks:
    - name: checkout Qroud
      git:
        repo:git@github.com:smarthall/Qroud.git
        dest: /opt/apps/Qroud force=no
      notify:
        - migrate db
        - generate static
        - restart httpd

  handlers:
    - name: migrate db
      command: ./manage.py migrate -all
      args:
        chdir: /opt/apps/Qroud

    - name: generate static
      command: ./manage.py collectstatic -c -noinput
      args:
        chdir: /opt/apps/Qroud

    - name: restart httpd
      service:
        name: httpd
        state: restarted
```

We can see that the `git` module is used to check out some public GitHub code, and if that caused anything to change, it triggers the `migrate db`, `generate static`, and `restart httpd` actions.

## The playbook modules

Using modules in playbooks is a little bit different from using them in the command line. This is mainly because we have many facts available from the previous modules and the `setup` module. Certain modules don't work in the Ansible command line because they require access to those variables. Other modules will work in the command-line version, but are able to provide enhanced functionalities when used in a playbook.

## The template module

One of the most frequently used examples of a module that requires facts from Ansible is the `template` module. This module allows us to design an outline of a configuration file and then have Ansible insert values in the right places. To perform this, Ansible uses the Jinja2 templating language. In reality, the Jinja2 templates can be much more complicated than this, including things such as conditionals, `for` loops, and macros. The following is an example of a Jinja2 configuration template for configuring BIND:

```
# {{ ansible_managed }}
options {
    listen-on port 53 {
        127.0.0.1;
        {% for ip in ansible_all_ipv4_addresses %}
            {{ ip }};
        {% endfor %}
    };
    listen-on-v6 port 53 { ::1; };
    directory      "/var/named";
    dump-file       "/var/named/data/cache_dump.db";
    statistics-file "/var/named/data/named_stats.txt";
    memstatistics-file "/var/named/data/named_mem_stats.txt";
};

zone "." IN {
    type hint;
    file "named.ca";
};

include "/etc/named.rfc1912.zones";
include "/etc/named.root.key";

{# Variables for zone config #}
{% if 'authoritativenames' in group_names %}
```

```
{% set zone_type = 'master' %}
{% set zone_dir = 'data' %}
{% else %}
{% set zone_type = 'slave' %}
{% set zone_dir = 'slaves' %}
{% endif %}

zone "internal.example.com" IN {
    type {{ zone_type }};
    file "{{ zone_dir }}/internal.example.com";
    {% if 'authoritative' not in group_names %}
        masters { 192.168.2.2; };
    {% endif %}
};
```

By convention, Jinja2 templates are named with the file extension of `.j2`; however, this is not strictly required. Now let's break this example down into its parts. The example starts with the following line of code:

```
# {{ ansible_managed }}
```

This line adds a comment at the top of the file that shows which template the file came from, the host, modification time of the template, and the owner. Putting this somewhere in the template as a comment is a good practice, and it ensures that people know what they should edit if they wish to alter it permanently.

Later, on the fifth line, there is a `for` loop:

```
{% for ip in ansible_all_ipv4_addresses %}
    {{ ip }};
{% endfor %}
```

`For` loops go through all the elements of a list once for each item in the list. They optionally assign the item to the variable of our choice so that we can use it inside the loop. This one loops across all the values in `ansible_all_ipv4_addresses`, which is a list provided by the `setup` module that contains all the IPv4 addresses that the machine has. Inside the `for` loop, it simply adds each of them into the configuration to make sure BIND will listen on that interface.

Comments are also possible in templates such as the one on line 24:

```
{# Variables for zone config #}
```

Anything in between `{# and #}` is simply ignored by the Jinja2 template processor. This allows us to add comments in the template that do not make it into the final file. This is especially handy if we are doing something complicated, setting variables within the template, or if the configuration file does not allow comments.

The next few lines are part of an `if` statement, which sets up `zone_type` and `zone_dir` variables for use later in the template:

```
{% if 'authorativenames' in group_names %}
    {% set zone_type = 'master' %}
    {% set zone_dir = 'data' %}
{% else %}
    {% set zone_type = 'slave' %}
    {% set zone_dir = 'slaves' %}
{% endif %}
```

Anything between `{% if %}` and `{% else %}` is ignored if the statement in the `if` tag is false. Here we check whether the value `authorativenames` is in the list of group names that apply to this host. If this is `true`, the next two lines are set two custom variables. `zone_type` is set to `master` and `zone_dir` is set to `data`. If this host is not in the `authorativenames` group, `zone_type` and `zone_dir` will be set to `slave` and `slaves`, respectively.

Finally, starting at line 33, we provide the actual configuration for the zone:

```
zone "internal.example.com" IN {
    type {{ zone_type }};
    file "{{ zone_dir }}/internal.example.com";
    {% if zone_type == 'slave' %}
        masters { 192.168.2.2; };
    {% endif %}
};
```

We set the type to the `zone_type` variable we created earlier, and the location to `zone_dir`. Finally we check whether the zone type is a slave, and if it is, we configure its master to a particular IP address.

To get this template to set up an authoritative nameserver, we need to create a group in our inventory file named `authorativenames` and add some hosts under it. How to do this was discussed back in *Chapter 1, Getting Started with Ansible*.

We can simply call the `templates` module and the facts from the machines will be sent through, including the groups the machine is in. This is as simple as calling any other module. The `template` module also accepts similar arguments to the `copy` module such as `owner`, `group`, and `mode`. Consider the following code for example:

```
---
- name: Setup BIND
  host: allnames
  tasks:
    - name: configure BIND
      template: src=templates/named.conf.j2 dest=/etc/named.conf
      owner=root group=named mode=0640
```

## The `set_fact` module

The `set_fact` module allows us to build our own facts on the machine inside an Ansible play. These facts can then be used inside templates or as variables in the playbook. Facts act just like arguments that come from modules such as the `setup` module, in that they work on a per-host basis. We should use this to avoid putting complex logic into templates. For example, if we are trying to configure a buffer to take a certain percentage of RAM, we should calculate the value in the playbook.

The following example shows how to use `set_fact` to configure a MySQL server to have an InnoDB buffer size of approximately half of the total RAM available on the machine:

```
---
- name: Configure MySQL
  hosts: mysqlservers
  tasks:
    - name: install MySql
      yum:
        name: mysql-server
        state: installed

    - name: Calculate InnoDB buffer pool size
      set_fact:
        innodb_buffer_pool_size_mb="{{ansible_memtotal_mb/2}}"

- name: Configure MySQL
  template:
    src: templates/my.cnf.j2
    dest: /etc/my.cnf
    owner: root
```

---

```

    group: root
    mode: 0644
    notify: restart mysql

- name: Start MySQL
  service:
    name: mysqld
    state: started
    enabled: yes

handlers:
- name: restart mysql
  service:
    name: mysqld
    state: restarted

```

The first task here simply installs MySQL using yum. The second task creates a fact by getting the total memory of the managed machine, dividing it by two, losing any non-integer remainder, and putting it in a fact called `innodb_buffer_pool_size_mb`. The next line then loads a template into `/etc/my.cnf` to configure MySQL. Finally, MySQL is started and set to start at boot time. A handler is also included to restart MySQL when its configuration changes.

The template then only needs to get the value of `innodb_buffer_pool_size` and place it into the configuration. This means we can re-use the same template in places where the buffer pool should be one-fifth of the RAM, or one-eighth, and simply change the playbook for those hosts. In this case, the template will look something like the following code snippet:

```

# {{ ansible_managed }}
[mysqld]
datadir=/var/lib/mysql
socket=/var/lib/mysql/mysql.sock
# Disabling symbolic-links is recommended to prevent assorted
# security risks
symbolic-links=0
# Settings user and group are ignored when systemd is used.
# If we need to run mysqld under a different user or group,
# customize our systemd unit file for mysqld according to the
# instructions in http://fedoraproject.org/wiki/Systemd

# Configure the buffer pool
innodb_buffer_pool_size = {{
    innodb_buffer_pool_size_mb|default(128) }}M

```

```
[mysqld_safe]
log-error=/var/log/mysqld.log
pid-file=/var/run/mysqld/mysqld.pid
```

We can see that in the previous template, we are simply putting the variables we get from the play into the template. If the template doesn't see the `innodb_buffer_pool_size_mb` fact, it simply uses a default of 128.

## The pause module

The `pause` module stops the execution of a playbook for a certain period of time. We can configure it to wait for a particular period, or we can make it prompt for the user to continue. While effectively useless when used from the Ansible command line, it can be very handy when used inside a playbook.

Generally, the `pause` module is used when we want the user to provide confirmation to continue, or if manual intervention is required at a particular point. For example, if we have just deployed a new version of a web application to a server, and we need to have the user check manually to make sure it looks okay before we configure them to receive production traffic, we can put a pause there. It is also handy to warn the user of a possible problem and give them the option of continuing. This will make Ansible print out the names of the servers and ask the user to press *Enter* to continue. If used with the `serial` key in the target section, it will ask once for each group of hosts that Ansible is running on. This way we can give the user the flexibility of running the deployment at our own pace while they interactively monitor the progress.

Less usefully, this module can simply wait for a specified period of time. This is not useful always as we usually don't know how long a particular action might take, and guessing might have disastrous outcomes. We should not use it for waiting for networked daemons to start up; instead we should use the `wait_for` module (described in the next section) for this task. The following play demonstrates using the `pause` module first in the user interactive mode and then in the timed mode:

```
---
- hosts: localhost
  tasks:
    - name: wait on user input
      pause:
        prompt: "Warning! Press ENTER to continue or CTRL-C to quit."

    - name: timed wait
      pause:
        seconds: 30
```

## The wait\_for module

The `wait_for` module is used to poll a particular TCP port and not continue until that port accepts a remote connection. The polling is done from the remote machine. If we only provide a port, or set the host argument to `localhost`, the poll will try to connect to the managed machine. We can utilize `local_action` to run the command from the controller machine and use the `ansible_hostname` variable as our host argument to make it try and connect to the managed machine from the controller machine.

This module is particularly useful for daemons that can take a while to start, or things that we want to run in the background. Apache Tomcat ships with an init script, which immediately returns when we try to start it, leaving Tomcat starting in the background. Depending on the application that Tomcat is configured to load, it might take anywhere between two seconds to 10 minutes to fully start up and be ready for connections. We can time our application's start up and use the `pause` module. However, the next deployment might take longer or shorter, and this will break our deployment mechanism. With the `wait_for` module, we have Ansible to recognize when Tomcat is ready to accept connections. The following is a play that does exactly this:

```
---
- hosts: webapps
  tasks:
    - name: Install Tomcat
      yum:
        name: tomcat7
        state: installed

    - name: Start Tomcat
      service:
        name: tomcat7
        state: started

    - name: Wait for Tomcat to start
      wait_for:
        port: 8080
        state: started
```

After the completion of this play, Tomcat should be installed, started, and ready to accept requests. We can append further modules to this example and depend on Tomcat being available and listening.



## The assemble module

The `assemble` module combines several files on the managed machine and saves them to another file on the managed machine. This is useful in playbooks when we have a `config` file which does not allow includes or globbing in its includes. This is useful for the `authorized_keys` file for say, the root user. The following play will send a bunch of SSH public keys to the managed machine, then make it assemble them all together and place it in the root user's home directory:

```
---
- hosts: all
  tasks:
    - name: Make a Directory in /opt
      file:
        path: /opt/sshkeys
        state: directory
        owner: root
        group: root
        mode: 0700

    - name: Copy SSH keys over
      copy:
        src: "keys/{{ item }}.pub"
        dest: "/opt/sshkeys/{{ item }}.pub"
        owner: root
        group: root
        mode: 0600
      with_items:
        - dan
        - kate
        - mal

    - name: Make the root users SSH config directory
      file:
        path: /root/.ssh
        state: directory
        owner: root
        group: root
        mode: 0700

    - name: Build the authorized_keys file
      assemble:
        src: /opt/sshkeys
        dest: /root/.ssh/authorized_keys
        owner: root
        group: root
        mode: 0700
```

By now, this should all look familiar. We might note the `with_items` key in the task that copies the keys over, and the `{{ items }}` variable. These will be explained later in *Chapter 3, Advanced Playbooks*, but all we need to know now is that whatever item we supply to the `with_items` key is substituted into the `{{ items }}` variable, similar to how a `for` loop works. This simply lets us easily copy many files to the remote host at once.

The last task shows the usage of the `assemble` module. We pass the directory containing the files to be concatenated into the output as the `src` argument, and then pass `dest` as the output file. It also accepts many of the same arguments (`owner`, `group`, and `mode`) as the other modules that create files. It also combines the files in the same order as the `ls -l` command lists them. This means we can use the same approach as `udev` and `rc.d`, and prepend numbers to the files to ensure that they end up in the correct order.

## The `add_host` module

The `add_host` module is one of the most powerful modules that are available in playbooks. `add_host` lets us dynamically add new machines inside a play. We can do this using the `uri` module to get a host from our **Configuration Management Database (CMDB)** and then adding it to the current play. This module will also add our host to a group, dynamically creating that group if it does not already exist.

The module simply takes a `name` and a `groups` argument, which are rather self-explanatory, and sets the `hostname` and `groups`. We can also send extra arguments, and these are treated in the same way in which extra values in the inventory file are treated. This means we can set `ansible_ssh_user`, `ansible_ssh_port`, and so on.

If we are using a cloud provider, such as RackSpace or Amazon EC2, there are modules available in Ansible that will let us manage our compute resources. We might decide to create machines at the start of the play, if we can't find them in the inventory. If we do this, we can use this module to add the machines to the inventory so that we can configure them later. Here is an example of using Google Compute Modules to do this:

```
---
- name: Create infrastructure
  hosts: localhost
  connection: local
  tasks:
    - name: Make sure the mailserver exists
      gce:
        image: centos-6
```

```
        name: mailserver
        tags: mail
        zone: us-central1-a
        register: mailserver
        when: '"mailserver" not in groups.all'

- name: Add new machine to inventory
  add_hosts:
    name: mailserver
    ansible_ssh_host: "{{ mailserver.instance_data[0].public_ip
  }}"
  groups: tag_mail
  when: not mailserver|skipped
```

## The group\_by module

In addition to creating hosts dynamically in our play, we can also create groups. The `group_by` module can create groups based on the facts about the machines, including the ones we set up ourselves using the `add_fact` module explained earlier. The `group_by` module accepts one argument, `key`, which takes the name of a group the machine will be added to. By combining this with the use of variables, we can make the module add a server to a group based on its operating system, virtualization technology, or any other fact that we have access to. We can then use this group in the target section of any subsequent plays, or in templates.

So if we want to create a group that groups the hosts by the operating system, we will call the module as follows:

```
---
- name: Create operating system group
  hosts: all
  tasks:
    - group_by: key=os_{{ ansible_distribution }}

- name: Run on CentOS hosts only
  hosts: os_CentOS
  tasks:
    - name: Install Apache
      yum: name=httpd state=latest

- name: Run on Ubuntu hosts only
  hosts: os_Ubuntu
  tasks:
    - name: Install Apache
      apt: pkg=apache2 state=latest
```

We can then use these groups to install packages using the right packager. In practice, this is often used to avoid Ansible outputting lots of "skipped" messages while it is executing. Instead of adding `when` clauses to each task that needs to be skipped, we can create a group for machines where the action should happen and then use a separate play to configure those machines separately. Here is an example of installing an ssl private key across Debian and RedHat machines without using a `when` clause:

```
---
- name: Categorize hosts
  hosts: all
  tasks:
    - name: Gather hosts by OS
      group_by:
        key: "os_{{ ansible_os_family }}"

- name: Install keys on RedHat
  hosts: os_RedHat
  tasks:
    - name: Install SSL certificate
      copy:
        src: sslcert.pem
        dest: /etc/pki/tls/private/sslcert.pem

- name: Install keys on Debian
  hosts: os_Debian
  tasks:
    - name: Install SSL certificate
      copy:
        src: sslcert.pem
        dest: /etc/ssl/private/sslcert.pem
```

## The slurp module

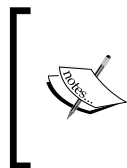
The `slurp` module grabs a file from the remote system, encodes it with base 64, and then returns the result. We can utilize the `register` keyword in order to place the contents into a fact. When using the `slurp` module to fetch files, we should be wary of the file size. This module loads the entire file into memory, so using `slurp` with large files can consume all available RAM and cause our system to crash. Files also need to be transferred from the managed machine to the controller machine, and for large files, this could take a considerable amount of time.

Combining this module with the `copy` module provides a way to copy files between two machines. This is demonstrated in the following playbook:

```
---
- name: Fetch a SSH key from a machine
  hosts: bastion01
  tasks:
    - name: Fetch key
      slurp:
        src: /root/.ssh/id_rsa.pub
        register: sshkey

- name: Copy the SSH key to all hosts
  hosts: all
  tasks:
    - name: Make directory for key
      file:
        state: directory
        path: /root/.ssh
        owner: root
        group: root
        mode: 0700

    - name: Install SSH key
      copy:
        contents: "{{ hostvars.bastion01.sshkey|b64decode }}"
        dest: /root/.ssh/authorized_keys
        owner: root
        group: root
        mode: 0600
```



Note that because the `slurp` module encodes the data with base 64, we have to use the jinja2 filter named `b64decode` to decode the data before the `copy` module can use it. Filters will be covered in more detail in *Chapter 3, Advanced Playbooks*.

## Windows playbook modules

Windows support is new to Ansible and as such, there aren't many modules available for it. Modules that are windows only are named beginning with `win_`. There are also a few modules available, which work on both Windows and Unix systems such as the `slurp` module, which we covered earlier.

Extra care should be taken in Windows modules to quote the path strings. Backslashes are an important character in both YAML, where they escape characters and in windows paths, where they denote directories. Because of this, YAML might confuse parts of our paths for escape sequences. To prevent this, we use single quotes on our strings. Additionally, if our path is a directory itself, we should leave off the trailing backspace so that YAML doesn't confuse the end of the string with an escape sequence. If we have to end our path with a backslash, make it a double backslash, and the second one will be ignored. The following are some examples of correct and incorrect strings:

```
# Correct
'C:\Users\Daniel\Documents\secrets.txt'
'C:\Program Files\Fancy Software Inc\Directory'
'D:\\' # \\ becomes \
# Incorrect
"C:\Users\Daniel\newcar.jpg" # \n becomes a new line
'C:\Users\Daniel\Documents\' # \' becomes '
```

## Cloud Infrastructure modules

Infrastructure modules allow us to not only manage the setup of our machines, but also the creation of those machines themselves. Apart from this, we can also automate much of the infrastructure surrounding them. This can be used as a simple replacement for services such as Amazon Cloud Formation.

When creating machines that we want to manage in a later play in the same playbook, we will want to use the `add_hosts` module that we discussed earlier in the chapter to add the machine to the in-memory inventory so that it can be the target of further plays. We might also wish to run the `group_by` module to arrange them into groups as we would arrange other machines. The `wait_for` module should also be used to check that the machine is responding to SSH connections before trying to manage it.

The Cloud Infrastructure modules can be a bit complicated to use, so we will be showing how to setup and install the Amazon modules. For details on how to configure the other modules, see their documentation using `ansible-doc`.

## The AWS modules

The AWS modules work similar to how most AWS tools work. This is because they use the python **boto** library, which is popular with many other tools and follows the conventions of the original AWS tools that were released by Amazon.

It is best to install boto the same way that we installed Ansible. For most use cases, we will be running the module on the managed machine, so we will only need to install the boto module there. We can install the boto library in the following ways:

- Centos/RHEL/Fedora: `yum install python-boto`
- Ubuntu: `apt-get install python-boto`
- Pip: `pip install boto`

Then we need to setup the correct environment variables. The easiest way to do this is by running the modules using the localhost connection on our local machine. If we do this, then the variables from our shell are passed through and automatically become available to the Ansible module. Here, are the variables that the boto library uses to connect to AWS:

Variable Name	Description
AWS_ACCESS_KEY	This is the access key for a valid IAM account
AWS_SECRET_KEY	This is the secret key corresponding to the access key above
AWS_REGION	This is the default region to use unless overridden

We can set these environment variables in our example using the following code:

```
export AWS_ACCESS_KEY="AKIAIOSFODNN7EXAMPLE"
export AWS_SECRET_KEY="wJalrXUtnFEMI/K7MDENG/bPxrFiCYEXAMPLEKEY"
export AWS_REGION="us-east-1"
```

These are just example credentials and will not work. Once we have these set, we can then use the AWS modules. In the next block of code, we combine several modules from this chapter to create a machine and add it to the inventory. Several features not yet discussed, such as `register` and `delegate_to`, are used in the following example, which will be covered in *Chapter 3, Advanced Playbooks*:

```
---
- name: Setup an EC2 instance
  hosts: localhost
  connection: local
  tasks:
    - name: Create an EC2 machine
      ec2:
        key_name: daniel-keypair
        instance_type: t2.micro
        image: ami-b66ed3de
        wait: yes
        group: webserver
```

```
    vpc_subnet_id: subnet-59483
    assign_public_ip: yes
    register: newmachines

- name: Wait for SSH to start
  wait_for:
    host: "{{ newmachines.instances[0].public_ip }}"
    port: 22
    timeout: 300
    delegate_to: localhost

- name: Add the machine to the inventory
  add_host:
    hostname: "{{ newmachines.instances[0].public_ip }}"
    groupname: new

- name: Configure the new machines
  hosts: new
  sudo: yes
  tasks:
    - name: Install a MOTD
      template:
        src: motd.j2
        dest: /etc/motd
```

## Summary

In this chapter, we covered the sections that are available in the playbook file. We also learned how to use variables to make our playbooks maintainable, how to trigger handlers when changes have been made, and finally, we looked at how certain modules are more useful when used inside a playbook. You can explore further modules provided with Ansible using the official documentation at [http://docs.ansible.com/modules\\_by\\_category.html](http://docs.ansible.com/modules_by_category.html).

In the next chapter, we will be looking into the more complex features of playbooks. This will allow us to build more complex playbooks capable of deploying and configuring entire systems.





# 3

## Advanced Playbooks

The playbooks that we have looked at so far are simple and just run a number of modules in order. Ansible allows much more control over the execution of your playbook. Using the following techniques, you should be able to perform even the most complex deployments:

- Running operations in parallel
- Looping
- Conditional execution
- Task delegation
- Extra variables
- Finding files with variables
- Environment variables
- External data lookups
- Storing data
- Processing data
- Debugging playbooks

### Running operations in parallel

By default, Ansible will only fork up to five times, so it will only run an operation on five different machines at once. If you have a large number of machines, or you have lowered this maximum fork value, then you may want to launch things asynchronously. Ansible's method for performing this is to launch the task and then poll for it to complete. This allows Ansible to start the job across all the required machines while still using the maximum forks.

To run an operation in parallel, use the `async` and `poll` keywords. The `async` keyword triggers Ansible to run the job in parallel, and its value will be the maximum time that Ansible will wait for the command to complete. The value of `poll` indicates to Ansible how often to poll to check if the command has been completed.

If you wanted to run `updatedb` across an entire cluster of machines, it might look like the following code:

```
- hosts: all
  tasks:
    - name: Install mlocate
      yum: name=mlocate state=installed

    - name: Run updatedb
      command: /usr/bin/updatedb
      async: 300
      poll: 10
```

You will notice that when you run the previous example on more than five machines, the `yum` module acts differently to the `command` module. The `yum` module will run on the first five machines, then the next five, and so on. The `command` module, however, will run across all the machines and indicate the status once complete.

If your command starts a daemon that eventually listens on a port, you can start it without polling so that Ansible does not check for it to complete. You can then carry on with other actions and check for completion later using the `wait_for` module. To configure Ansible to not wait for the job to complete, set the value of `poll` to 0.

Finally, if your task takes an extremely long time to run, you can tell Ansible to wait for the job as long as it takes. To do this, set the value of `async` to 0.

You will want to use Ansible's polling in the following situations:

- You have a long-running task that may hit the timeout
- You need to run an operation across a large number of machines
- You have an operation for which you don't need to wait to complete

There are also a few situations where you should not use `async` or `poll`:

- If your job acquires locks that prevent other things from running
- Your job only takes a short time to run

## Looping

Ansible allows you to repeat a module several times with different inputs, for example, if you had several files that should have similar permissions set. This can save you a lot of repetition and allows you to iterate over facts and variables.

To do this, you can use the `with_items` key on an action and set the value to the list of items that you are going to iterate over. This will create a variable for the module named `item`, which will be set to each item in turn as your module is iterated over. Some modules such as `yum` will optimize this so that instead of doing a separate transaction for each package, they will operate on all of them at once.

Using `with_items`, the code looks like this:

```
tasks:
- name: Secure config files file:
  path: "/etc/{{ item }}"
  mode: 0600
  owner: root
  group: root
  with_items:
  - my.cnf
  - shadow
  - fstab
```

In addition to looping over fixed items, or a variable, Ansible also provides us a tool called **lookup plugins**. These plugins allow you to tell Ansible to fetch the data from somewhere externally. For example, you might want to find all the files that match a particular pattern, and then upload them.

In this example, we upload all the public keys in a directory and then assemble them into an `authorized_keys` file for the root user, as shown in the following example:

```
tasks:
- name: Make key directory
  file:
    path: /root/.sshkeys
    ensure: directory
    mode: 0700
    owner: root
    group: root
- name: Upload public keys
  copy:
    src: "{{ item }}"
    dest: /root/.sshkeys
    mode: 0600
    owner: root
```

```
    group: root
  with_fileglob:
    - keys/*.pub
- name: Assemble keys into authorized_keys file
  assemble:
    src: /root/.sshkeys
    dest: /root/.ssh/authorized_keys
    mode: 0600
    owner: root
    group: root
```


Repeating modules can be used in the following situations:

- Repeating a module many times with similar settings
- Iterating over all the values of a list
- Creating many files for later use with the `assemble` module to combine into one large file
- Copying a directory of files when combined with the `with_fileglob` lookup plugin

## Conditional execution

Some modules, such as the `copy` module, provide mechanisms to configure it to skip the execution of the module. You can also configure your own skip conditions that will only execute the module if they resolve to `true`. This can be handy if your servers use different packaging systems or have different filesystem layouts. It can also be used with the `set_fact` module to allow you to compute many different things.

To skip a module, you can use the `when` key; this lets you provide a condition. If the condition you set resolves to `false`, then the module will be skipped. The value that you assign to `when` is a Python expression. You can use any of the variables or facts available to you at this point.

 If you want to process some of the items in the list depending on a condition, then simply use the `when` clause. The `when` clause is processed separately for each item in the list; the item being processed is available as a variable using `{{ item }}`.

The following code is an example showing how to choose between `apt` and `yum` for both Debian and Red Hat systems.

```
---
- name: Install VIM
```

---

```

hosts: all
tasks:
  - name: Install VIM via yum
    yum:
      name: vim-enhanced
      state: installed
      when: ansible_os_family == "RedHat"

  - name: Install VIM via apt
    apt:
      name: vim
      state: installed
      when: ansible_os_family == "Debian"

  - name: Unexpected OS family
    debug:
      msg: "OS Family {{ ansible_os_family }} is not supported"
      fail: yes
      when: ansible_os_family != "RedHat" and ansible_os_family
!= "Debian"

```

There is also a third clause to print a message and fail if the OS is not recognized.



This feature can be used to pause at a particular point and will wait for the user intervention to continue. Normally, when Ansible encounters an error, it will simply stop what it is doing without running any handlers. With this feature, you can add the pause module with a condition on it that triggers in unexpected situations. This way the pause module will be ignored in a normal situation; however, in unexpected circumstances, it will allow the user to intervene and continue when it is safe to do so. The task would look like this:

```

name: pause for unexpected conditions
pause: prompt="Unexpected OS"
when: ansible_os_family != "RedHat"

```

There are numerous uses of skipping actions; here are a few of them:

- Working around differences in operating systems
- Prompting a user and only then performing actions that they request
- Improving performance by avoiding a module that you know won't change anything but may take a while to do so
- Refusing to alter systems that have a particular file present
- Checking if custom scripts have already been run

## Task delegation

Ansible, by default, runs its tasks all at once on the configured machine. This is great when you have a whole bunch of separate machines to configure, or if each of your machines is responsible for communicating its status to the other remote machines. However, if you need to perform an action on a different host than the one Ansible is operating on, you can use a delegation.

Ansible can be configured to run a task on a different host other than the one that is being configured using the `delegate_to` key. The module will still run once for every machine, but instead of running on the target machine, it will run on the delegated host. The facts available will be the ones applicable to the current host. Here, we show a playbook that will use the `get_url` option to download the configuration from a bunch of web servers.

```
---
- name: Fetch configuration from all webservers
  hosts: webservers
  tasks:
    - name: Get config
      get_url:
        dest: "configs/{{ ansible_hostname }}"
        force: yes
        url: "http://{{ ansible_hostname }}/diagnostic/config"
      delegate_to: localhost
```

If you are delegating to the `localhost`, you can use a shortcut when defining the action that automatically uses the local machine. If you define the key of the action line as `local_action`, then the delegation to `localhost` is implied. If we were to have used this in the previous example, it would be slightly shorter and will look like this:

```
--- #1
- name: Fetch configuration from all webservers      #2
  hosts: webservers      #3
  tasks:      #4
    - name: Get config      #5
      local_action: get_url dest=configs/{{ ansible_hostname
        }}.cfg url=http://{{ ansible_hostname
        }}/diagnostic/config      #6
```

Delegation is not limited to the local machine. You can delegate to any host that is in the inventory. Some other reasons why you might want to delegate are:

- Removing a host from a load balancer before deployment
- Changing DNS to direct traffic away from a server you are about to change

- Creating an iSCSI volume on a storage device
- Using an external server to check whether access outside the network works

## Extra variables

You may have seen in our template example in the previous chapter that we used a variable named `group_names`. This is one of the magic variables that are provided by Ansible itself. At the time of writing, there are seven such variables, which are described in the upcoming sections.

## The hostvars variable

The `hostvars` variable allows you to retrieve variables of all the hosts that the current play has dealt with. If the `setup` module hasn't yet been run on that managed host in the current play, only its variables will be available. You can access it like you would access other complex variables, such as `{{hostvars.hostname.fact}}`, so to get the Linux distribution running on a server named `ns1`, it would be `{{hostvars.ns1.ansible_distribution}}`. The following example sets a variable called `zone master` to the server named `ns1`. It then calls the `template` module, which would use this to set the masters for each zone.

```
---
- name: Setup DNS Servers
  hosts: allnameservers
  tasks:
    - name: Install BIND
      yum:
        name: named
        state: installed

- name: Setup Slaves
  hosts: slavenameservers
  tasks:
    - name: Get the masters IP
      set_fact:
        dns_master: "{{ hostvars.ns1.ansible_default_ipv4.address }}"

- name: Configure BIND
  template:
    dest: /etc/named.conf
    src: templates/named.conf.j2
```





Using `hostvars`, you can further abstract templates from your environment. If you nest your variable calls, then instead of placing an IP address in the variable section of the play, you can add the hostname. To find the address of a machine named in the `the_machine` variable you would use, `{{ hostvars.[the_machine].default_ipv4.address }}`.

## The groups variable

The `groups` variable contains a list of all hosts in the inventory grouped by the inventory group. This lets you get access to all the hosts that you have configured. This is potentially a very powerful tool. It allows you to iterate across a whole group and for every host apply an action to the current machine.

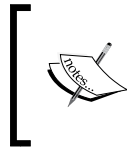
```
---
- name: Configure the database
  hosts: dbservers
  user: root
  tasks:
    - name: Install mysql
      yum:
        name: "{{ item }}"
        state: installed
      with_items:
        - mysql-server
        - MySQL-python

    - name: Start mysql
      service:
        name: mysqld
        state: started
        enabled: true

    - name: Create a user for all app servers
      with_items: groups.appservers
      mysql_user:
        name: kate

        password: test

        host: "{{ hostvars.[item].ansible_eth0.ipv4.address }}"
        state: present
```



The groups variable does not contain the actual hosts in the group; it contains strings representing their names in the inventory. This means you have to use nested variable expansion to get to the `hostvars` variable, if needed.

You can even use this variable to create the `known_hosts` files for all of your machines containing the `host` keys of all the other machines. This would allow you to then SSH from one machine to another without confirming the identity of the remote host. It would also handle removing machines when they leave service or updating them when they are replaced. The following is a template for a `known_hosts` file that does this:

```
{% for host in groups['all'] %}
{{ hostvars[host]['ansible_hostname'] }}
{{ hostvars[host]['ansible_ssh_host_key_rsa_public'] }}
{% endfor %}
```

The playbook that uses this template would look like this:

```
---
hosts: all
tasks:
- name: Setup known hosts
  hosts: all
  tasks:
    - name: Create known_hosts
      template:
        src: templates/known_hosts.j2
        dest: /etc/ssh/ssh_known_hosts

        owner: root

        group: root
        mode: 0644
```

## The group\_names variable

The `group_names` variable contains a list of strings with the names of all the groups the current host is in. This is not only useful for debugging, but also for conditionals detecting group membership. This was used in the last chapter to set up a nameserver.

This variable is mostly useful for skipping a task or in a template as a condition. For instance, if you had two configurations for the SSH daemon, one secure and one less secure, but you only wanted the secure configuration on the machines in the secure group, you would do it like this:

```
- name: Setup SSH
  hosts: sshservers
  tasks:
    - name: For secure machines
      set_fact:
        sshconfig: files/ssh/sshd_config_secure
      when: "'secure' in group_names"

    - name: For non-secure machines
      set_fact:
        sshconfig: files/ssh/sshd_config_default
      when: "'secure' not in group_names"

    - name: Copy over the config
      copy:
        src: "{{ sshconfig }}"
        dest: /tmp/sshd_config
```



In the previous example, we used the `set_fact` module to set the fact for each case, and then used the `copy` module. We could have used the `copy` module in place of the `set_facts` modules and used one fewer task. The reason this was done is that the `set_fact` module runs locally and the `copy` module runs remotely. When you use the `set_facts` module first and only call the `copy` module once, the copies are made on all the machines in parallel. If you used two `copy` modules with conditions, then each would execute on the relevant machines separately. Since `copy` is the longer task of the two, it benefits the most from running in parallel.

## The `inventory_hostname` variable

The `inventory_hostname` variable stores the hostname of the server as recorded in the inventory. You should use this if you have chosen not to run the `setup` module on the current host, or if for various reasons, the value detected by the `setup` module is not correct. This is useful when you are doing the initial setup of the machine and changing the hostname.

## The inventory\_hostname\_short variable

The `inventory_hostname_short` variable is the same as the previous variable; however, it only includes the characters up to the first dot. So for `host.example.com`, it would return `host`.

## The inventory\_dir variable

The `inventory_dir` variable is the path name of the directory containing the inventory file.

## The inventory\_file variable

The `inventory_file` variable is the same as the previous one, except that it also includes the filename.

## Finding files with variables


All modules can take variables as part of their arguments by dereferencing them with `{{` and `}}`. You can use this to load a particular file based on a variable. For example, you might want to select a different `config` file for NRPE (a Nagios check daemon) based on the architecture in use. Here is how that would look:

```
---
- name: Configure NRPE for the right architecture
  hosts: ansibletest
  user: root
  tasks:
    - name: Copy in the correct NRPE config file
      copy:
        src: "files/nrpe.{{ ansible_architecture }}.conf"
        dest: "/etc/nagios/nrpe.cfg"
```

In the `copy` and the `template` modules, you can also configure Ansible to look for a set of files, and it finds them using the first one. This lets you configure a file to look for; if that file is not found, a second will be used, and so on until the end of the list is reached. If the file is not found, then the module will fail. The feature is triggered using the `first_available_file` key, and referencing `{{ item }}` in the action. The following code is an example of this feature:

```
---
- name: Install an Apache config file
  hosts: ansibletest
  user: root
```

```
tasks:
  - name: Get the best match for the machine
    copy:
      dest: /etc/apache.conf
      src: "{{ item }}"
    first_available_file:
      - "files/apache/{{ ansible_os_family }}-{{ ansible_architecture
        }}.cfg"
      - "files/apache/default-{{ ansible_architecture }}.cfg"
      - files/apache/default.cfg
```

 Remember that you can run the setup module from the Ansible command-line tool. This comes in handy when you are making heavy use of variables in your playbooks or templates. To check what facts will be available for a particular play, simply copy the value of the host pattern and run the following command:

```
ansible [host pattern] -m setup
```

On a CentOS x86\_64 machine, this configuration will first look for the RedHat-x86\_64.cfg file upon navigating through files/apache/. If that file does not exist, it will look for the default-x86\_64.cfg file upon navigating through file/apache/, and finally if nothing exists, it'll try and use default.cfg.

## Environment variables

Often, Unix commands take advantage of certain environment variables. Prevalent examples of this are C makefiles, installers, and the AWS command-line tools. Fortunately, Ansible makes this really easy. If you want to upload a file on the remote machine to Amazon S3, you can set the Amazon access key as follows. You will also see that we install EPEL so that we can install pip, and pip is used to install the AWS tools.

```
---
- name: Upload a remote file via S3
  hosts: ansibletest
  user: root
  tasks:
    - name: Setup EPEL
      command: >
        rpm -ivh http://download.fedoraproject.org/pub/epel/6/i386/
        epel-release-6-8.noarch.rpm
        creates=/etc/yum.repos.d/epel.repo

    - name: Install pip
```

```

yum:
  name: python-pip
  state: installed

- name: Install the AWS tools
  pip:
    name: awscli
    state: present

- name: Upload the file
  shell: >
    aws s3 put-object
    --bucket=my-test-bucket
    --key={{ ansible_hostname }}/fstab
    --body=/etc/fstab
    --region=eu-west-1
  environment:
    AWS_ACCESS_KEY_ID: XXXXXXXXXXXXXXXXXXXX
    AWS_SECRET_ACCESS_KEY: XXXXXXXXXXXXXXXXXXXX

```



Internally, Ansible sets the environment variable into the Python code; this means any module that already uses environment variables can take advantage of the ones set here. If you write your own modules, you should consider if certain arguments would be better used as environment variables instead of arguments.

Some Ansible modules, such as `get_url`, `yum`, and `apt`, will also use environment variables to set their proxy server. Some of the other situations where you might want to set environment variables are as follows:

- Running application installers
- Adding extra items to the path when using the `shell` module
- Loading libraries from a place not included in the system library search path
- Using an `LD_PRELOAD` hack while running a module

## External data lookups

Ansible introduced the lookup plugins in version 0.9. These plugins allow Ansible to fetch data from outside sources. Ansible provides several plugins, but you can also write your own. This really opens the doors and allows you to be flexible in your configuration.

Lookup plugins are written in Python and run on the controlling machine. They are executed in two different ways: direct calls and `with_*` keys. Direct calls are useful when you want to use them like you would use variables. Using the `with_*` keys is useful when you want to use them as loops. In an earlier section, we covered `with_fileglob`, which is an example of this.

In the next example, we use a lookup plugin directly to get the `http_proxy` value from environment and send it through to the configured machine. This makes sure that the machines we are configuring will use the same proxy server to download the file.

```
---
- name: Downloads a file using a proxy
  hosts: all
  tasks:
    - name: Download file
      get_url:
        dest: /var/tmp/file.tar.gz
        url: http://server/file.tar.gz
      environment:
        http_proxy: "{{ lookup('env', 'http_proxy') }}"
```



You can also use lookup plugins in the variable section. This doesn't immediately lookup the result and put it in the variable as you might assume; instead, it stores it as a macro and looks it up every time you use it. This is good to know if you are using something, the value of which might change over time.

Using lookup plugins in the `with_*` form will allow you to iterate over things you wouldn't normally be able to. You can use any plugin like this, but ones that return a list are most useful. In the following code, we show how to dynamically register a webapp farm.

```
---
- name: Registers the app server farm
  hosts: localhost
  connection: local
  vars:
    hostcount: 5
  tasks:
    - name: Register the webapp farm
      local_action: add_host name={{ item }} groupname=webapp
      with_sequence: start=1 end={{ hostcount }} format=webapp%02x
```

If you were using this example, you would append a task to create each as a virtual machine and then a new play to configure each of them.

Situations where lookup plugins are useful are as follows:

- Copying a whole directory of Apache config to a `conf.d` style directory
- Using environment variables to adjust what the playbooks does
- Getting configuration from DNS TXT records
- Fetching the output of a command into a variable

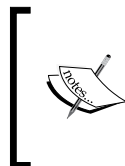
## Storing results

Almost every module outputs something, even the `debug` module. Most of the time, the only variable used is the one named `changed`. The `changed` variable helps Ansible decide whether to run handlers or not and which color to print the output in. However, if you wish to, you can store the returned values and use them later in the playbook. In this example, we look at the mode in the `/tmp` directory and create a new directory named `/tmp/subtmp` with the same mode as shown here.

```
---
- name: Using register
  hosts: ansibletest
  user: root
  tasks:
    - name: Get /tmp info
      file:
        dest: /tmp
        state: directory
        register: tmp

    - name: Set mode on /var/tmp
      file:
        dest: /tmp/subtmp
        mode: "{{ tmp.mode }}"
        state: directory
```

Some modules, such as the `file` module in the previous example, can be configured to simply give information. By combining this with the `register` feature, you can create playbooks that can examine the environment and calculate how to proceed.



Combining the `register` feature and the `set_fact` module allows you to perform data processing on data you receive back from the modules. This allows you to compute values and perform data processing on these values. This makes your playbooks even smarter and more flexible than ever.



Register allows you to make your own facts about hosts from modules already available to you. This can be useful in many different circumstances:

- Getting a list of files in a remote directory and downloading them all with `fetch`
- Running a task when a previous task changes, before the handlers run
- Getting the contents of the remote host SSH key and building a `known_hosts` file

## Processing data

Ansible uses Jinja2 filters to allow you to transform data in ways that aren't possible with basic templates. We use filters when the data available to us in our playbooks is not in the format we want, or require further complex processing before it can be used with modules or templates. Filters can be used anywhere we would normally use a variable, such as in templates, as arguments to modules, and in conditionals. Filters are used by providing the variable name, a pipe character, and then the filter name. We can use multiple filter names separated with pipe characters to use multiple pipes, which are then applied left to right. Here is an example where we ensure that all users are created with lowercase usernames:

```
---
- name: Create user accounts
  hosts: all
  vars:
    users:
  tasks:
    - name: Create accounts
      user: name={{ item|lower }} state=present
      with_items:
        - Fred
        - John
        - DanielH
```

Here are a few popular filters that you may find useful:

Filter	Description
<code>min</code>	When the argument is a list it returns only the smallest value.
<code>max</code>	When the argument is a list it returns only the largest value.
<code>random</code>	When the argument is a list it picks a random item from the list.
<code>changed</code>	When used on a variable created with the <code>register</code> keyword, it returns <code>true</code> if the task changed anything; otherwise, it returns <code>false</code> .

Filter	Description
<code>failed</code>	When used on a variable created with the <code>register</code> keyword, it returns <code>true</code> if the task failed; otherwise, it returns <code>false</code> .
<code>skipped</code>	When used on a variable created with the <code>register</code> keyword, it returns <code>true</code> if the task changed anything; otherwise, it returns <code>false</code> .
<code>default(X)</code>	If the variable does not exist, then the value of <code>X</code> will be used instead.
<code>unique</code>	When the argument is a list, return a list without any duplicate items.
<code>b64decode</code>	Convert the base64 encoded string in the variable to its binary representation. This is useful with the <code>slurp</code> modules, as it returns its data as a base64 encoded string.
<code>replace(X, Y)</code>	Return a copy of the string with any occurrences of <code>X</code> replaced by <code>Y</code> .
<code>join(X)</code>	When the variable is a list, return a string with all the entries separated by <code>X</code> .

## Debugging playbooks

There are a few ways in which you can debug a playbook. Ansible includes both a verbose mode and a `debug` module specifically for debugging. You can also use modules such as `fetch` and `get_url` for help. These debugging techniques can also be used to examine how modules behave when you wish to learn how to use them.

### The debug module

Using the `debug` module is really quite simple. It takes two optional arguments, `msg` and `fail.msg` to set the message that will be printed by the module and `fail`, if set to `yes`, indicates a failure to Ansible, which will cause it to stop processing the playbook for that host. We used this module earlier in the skipping modules section to bail out of a playbook if the operating system was not recognized.

In the following example, we will show how to use the `debug` module to list all the interfaces available on the machine:

```
---
- name: Demonstrate the debug module
  hosts: ansibletest
  user: root
  vars:
    hostcount: 5
  tasks:
    - name: Print interface
      debug:
        msg: "{{ item }}"
      with_items: ansible_interfaces
```

The preceding code gives the following output:

```
PLAY [Demonstrate the debug module] *****

GATHERING FACTS *****
ok: [ansibletest]

TASK: [Print interface] *****
ok: [ansibletest] => (item=lo) => {"item": "lo", "msg": "lo"}
ok: [ansibletest] => (item=eth0) => {"item": "eth0", "msg": "eth0"}

PLAY RECAP *****
ansibletest      : ok=2    changed=0    unreachable=0
failed=0
```

As you can see, the debug module is easy to use to see the current value of a variable during the play.

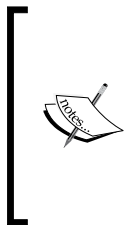
## The verbose mode

Your other option for debugging is the verbose option. When running Ansible with verbose, it prints out all the values that were returned by each module after it runs. This is especially useful if you are using the `register` keyword introduced in the previous section. To run `ansible-playbook` in verbose mode, simply add `--verbose` to your command line as follows:

```
ansible-playbook --verbose playbook.yml
```

## The check mode

In addition to the verbose mode, Ansible also includes a check mode and a diff mode. You can use the check mode by adding `--check` to the command line, and `--diff` to use the diff mode. The check mode instructs Ansible to walk through the play without actually making any changes to remote systems. This allows you to obtain a listing of the changes that Ansible plans to make to the configured system.



It is important here to note that the check mode of Ansible is not perfect. Any modules that do not implement the check feature are skipped. Additionally, if a module is skipped that provides more variables, or the variables depend on a module actually changing something (such as file size), then they will not be available. This is an obvious limitation when using the `command` or `shell` modules

The diff mode shows the changes that are made by the `template` module. This limitation is because the `template` file only works with text files. If you were to provide a diff of a binary file from the `copy` module, the result would almost be unreadable. The diff mode also works with the `check` mode to show you the planned changes that were not made due to being in check mode.

## The pause module

Another technique is to use the `pause` module to pause the playbook while you examine the configured machine as it runs. This way, you can see changes that the modules have made at the current position in the play, and then watch while it continues with the rest of the play.

## Summary

In this chapter, we explored the more advanced details of writing playbooks. You should now be able to use features such as delegation, looping, conditionals, and fact registration to make your plays much easier to maintain and edit. We also looked at how to access information from other hosts, configure the environment for a module, and gather data from external sources. Finally, we covered some techniques for debugging plays that are not behaving as expected.

In the next chapter, we will be covering how to use Ansible in a larger environment. It will include methods for improving the performance of your playbooks that might be taking a long time to execute. We will also cover a few more features that make plays maintainable, particularly splitting them into many parts by purpose.



# 4

## Larger Projects

Until now we have been looking at single plays in one playbook file. This approach will work for simple infrastructures, or when using Ansible as a simple deployment mechanism. However, if you have a large and complicated infrastructure, then you will need to take actions to prevent things from going out of control. This chapter will include the following topics:

- Separating your playbooks into different files, and including them from some other location
- Using roles to include multiple files that perform a similar function
- Methods for increasing the speed at which Ansible configures your machines

### Includes

One of the first issues you will face with a complex infrastructure is that your playbooks will rapidly increase in size. Large playbooks can become difficult to read and maintain. Ansible allows you to combat this problem by way of includes.

Includes allow you to split your plays into multiple sections. You can then include each section from other plays. This allows you to have several different parts built for a different purpose, all included in a main play.

There are four types of includes, namely, variable includes, playbook includes, task includes, and handler includes. Including variables from an external `vars_file` files has been discussed already in *Chapter 2, Simple Playbooks*. The following is a description of what each includes does:

- **Variable includes:** They allow you to put your variables in external YAML files
- **Playbook includes:** They are used to include plays from other files in a single play

- **Task includes:** They let you put common tasks in other files and include them wherever required
- **Handler includes:** They let you put all your handlers at one place

We will be looking at these includes in the following section; however, including variables from an external `vars_file` files has been discussed already in *Chapter 2, Simple Playbooks*, so we will not be discussing it in detail.

## Task includes

Task includes can be used when you have a lot of common tasks that will be repeated. For example, you may have a set of tasks that removes a machine from monitoring and a load balancer before you can configure it. You can put these tasks in a separate YAML file, and then include them from your main task.

Task includes inherit the facts from the play they are included from. You can also provide your own variables, which are passed into the task and are available for use.

Finally, task includes can have conditionals applied to them. If you do this, conditionals will separately be added to each included task by Ansible automatically. The tasks are all still included. In most cases, this is not an important distinction; however, in circumstances where variables may change, it is.

The file to include as a task includes contains a list of tasks. If you assume the existence of any variables, hosts, or groups, then you should state them in comments at the top of the file. This makes it easier for people who wish to reuse the file later.

So, if you wanted to create a bunch of users and set up their environment with their public keys, you would split out the tasks that do a single user to one file. This file will look similar to the following code:

```
---
# Requires a user variable to specify user to setup
- name: Create user account
  user:
    name: "{{ user }}"
    state: present

- name: Make user SSH config dir
  file:
    path: "/home/{{ user }}/.ssh"
    owner: "{{ user }}"
    group: "{{ user }}"
    mode: 0600
    state: directory
```

---

```
- name: Copy in public key
  copy:
    src: "keys/{{ user }}.pub"
    dest: "/home/{{ user }}/.ssh/authorized_keys"
    mode: 0600
    owner: "{{ user }}"
    group: "{{ user }}"
```

We expect that a variable named `user` will be passed to us, and that their public key will be in the `keys` directory. The account is created, the `ssh config` directory is made, and finally we can copy this in their public key. The easiest way to use this config file would be to include it with the `with_items` keyword you learned about in *Chapter 3, Advanced Playbooks*. This will look similar to the following code:

```
---
- hosts: ansibletest
  user: root
  tasks:
    - include: usersetup.yml user={{ item }}
      with_items:
        - mal
        - dan
        - kate
```

## Handler includes

When writing Ansible playbooks, you will constantly find yourself reusing the same handlers multiple times. For instance, a handler used to restart MySQL is going to look the same everywhere. To make this easier, Ansible allows you to include other files in the handlers section. Handler includes look the same as task includes. You should make sure to include a name on each of your handlers; otherwise, you will not be able to refer to them easily in your tasks. A handler includes file looks similar to the following code:

```
---
- name: config sendmail
  command: make -C /etc/mail
  notify: reload sendmail

- name: config aliases
  command: newaliases
  notify: reload sendmail

- name: reload sendmail
  service:
```




```
    name: sendmail
    state: reloaded

- name: restart sendmail
  service:
    name: sendmail
    state: restarted
```

This file provides several common tasks that you would want to handle after configuring `sendmail`. By including the following handlers in their own files, you can easily reuse them whenever you need to change the `sendmail` configuration:

- The first handler regenerates the `sendmail` database's config file and triggers a reload file of `sendmail` later
- The second handler initializes the `aliases` database, and also schedules a reload file of `sendmail`
- The third handler reloads `sendmail`; it may be triggered by the previous two jobs, or it may be triggered directly from a task
- The fourth handler restarts `sendmail` when triggered; this is useful if you upgrade `sendmail` to a new version

 Handlers can trigger other handlers provided they only trigger the ones specified later, instead of the triggered ones. This means you can set up a series of cascading handlers that call each other. This saves you from having long lists of handlers in the `notify` section of tasks.

Using the preceding handler file is easy now. We simply need to remember that if we change a `sendmail` configuration file, then we should trigger `config sendmail`, and if we change the `aliases` file, we should trigger `config aliases`. The following code shows us an example of this:

```
---
hosts: mailers
tasks:
  - name: update sendmail
    yum:
      name: sendmail
      state: latest
      notify: restart sendmail

  - name: configure sendmail
    template:
```

```
    src: templates/sendmail.mc.j2
    dest: /etc/mail/sendmail.mc
    notify: config sendmail

handlers:
- include: sendmailhandlers.yml
```

This playbook makes sure `sendmail` is installed. If it isn't installed, or if it isn't running the latest version, then it installs it or updates it. After it is updated, it schedules a restart so that we can be confident that the latest version will be running once the playbook is done. In the next step, we replace the `sendmail` configuration file with our template. If the `config` file was changed by the template, then the `sendmail` configuration files will be regenerated, and finally `sendmail` will be reloaded.

## Playbook includes

Playbook includes should be used when you want to include a whole set of tasks designated for a set of machines. For example, you may have a play that gathers the host keys of several machines and builds a `known_hosts` file to copy to all the machines.

While `task includes` allows you to include tasks, `playbook includes` allows you to include whole plays. This allows you to select the hosts you wish to run on, and provide handlers for notify events. Because you are including whole playbook files, you can also include multiple plays.

Playbook includes allows you to embed fully self-contained files. It is for this reason that you should provide any variables that it requires. If they depend on any particular set of hosts or groups, this should be noted in a comment at the top of the file.

This is handy when you wish to run multiple different actions at once. For example, let's say we have a playbook that switches to our DR site, named `drfailover.yml`, another named `upgradeapp.yml` that upgrades the app, another named `drfailback.yml` that fails back, and finally `drupgrade.yml`. All these playbooks might be valid to use separately; however, when performing a site upgrade, you will probably want to perform them all at once. You can do this as shown in the following code:

```
---
- include "drfailover.yml"
- include "upgradeapp.yml"
- include "drfailback.yml"

- name: Notify management
  hosts: local
```

```
tasks:
  - mail
    to: "mgmt-team@example.com"
    msg: 'The application has been upgraded and is now live'

  - include "drupgrade.yml"
```

As you can see, you can put full plays in the playbooks that you are including other playbooks into.

## Roles

If your playbooks start expanding beyond what includes can help you solve, or you start gathering a large number of templates, you may want to use roles. Roles in Ansible allow you to group files together in a defined structure. They are essentially an extension to includes that handles a few things automatically, and this helps you organize them inside your repository.

Roles allow you to place your variables, files, tasks, templates, and handlers in a folder, and then easily include them. You can also include other roles from within roles, which effectively creates a tree of dependencies. Similar to task includes, they can have variables passed to them. Using these features, you should be able to build self-contained roles that are easy to share with others.

Roles are commonly set up to manage services provided by machines, but they can also be daemons, options, or simply characteristics. Things you may want to configure in a role are as follows:

- Web servers, such as Nginx or Apache
- Messages of the day customized for the security level of the machine
- Database servers running PostgreSQL or MySQL

To manage roles in Ansible, perform the following steps:

1. Create a folder named `roles` with your playbooks.
2. In the `roles` folder, make a folder for each role that you would like.
3. In the folder for each role, make folders named `files`, `handlers`, `meta`, `tasks`, `templates`, and finally `vars`. If you aren't going to use all these, you can leave out the ones you don't need. Ansible will silently ignore any missing files or directories when using roles.
4. In your playbooks, add the keyword `roles` followed by a list of roles that you would like to apply to the hosts.

5. For example, if you had the `common`, `apache`, `website1`, and `website2` roles, your directory structure would look similar to the following example. The `site.yml` file is for reconfiguring the entire site, and the `webserver1.yml` and `webserver2.yml` files are for configuring each web server farm.

```
.
├── inventory.ini
├── roles
│   ├── apache
│   │   ├── files
│   │   ├── handlers
│   │   │   └── main.yml
│   │   ├── meta
│   │   ├── tasks
│   │   │   └── main.yml
│   │   ├── templates
│   │   │   └── httpd.conf.j2
│   │   └── vars
│   │       └── main.yml
│   ├── common
│   │   ├── files
│   │   │   └── bashrc
│   │   ├── handlers
│   │   ├── meta
│   │   ├── tasks
│   │   │   └── main.yml
│   │   ├── templates
│   │   │   └── motd.j2
│   │   └── vars
│   │       └── main.yml
│   ├── website1
│   │   ├── files
│   │   ├── handlers
│   │   │   └── main.yml
│   │   ├── meta
│   │   ├── tasks
│   │   │   └── main.yml
│   │   ├── templates
│   │   │   ├── environment.yml.j2
│   │   │   └── website1.conf.j2
│   │   └── vars
│   │       └── main.yml
│   └── website2
│       ├── files
│       ├── handlers
│       │   └── main.yml
│       ├── meta
│       ├── tasks
│       │   └── main.yml
│       ├── templates
│       │   ├── environment.yml.j2
│       │   └── website2.conf.j2
│       └── vars
│           └── main.yml
├── website1.yml
└── website2.yml
```

The following file is what could be in `website1.yml`. It shows a playbook that applies the `common`, `apache`, and `website1` roles to the `website1` group in the inventory. The `website1` role is included using a more verbose format that allows us to pass variables to the role, as follows:

```
---
- name: Setup servers for website1.example.com
  hosts: website1
  roles:
    - common
    - apache
    - { role: website1, port: 80 }
```

For the role named `common`, Ansible will then try to load `roles/common/tasks/main.yml` as a task include, `roles/common/handlers/main.yml` as a handler include, and `roles/common/vars/main.yml` as a variable file include. If all of these files are missing, Ansible will throw an error; however, if one of the files exists, then the others, if missing, will be ignored. The following directories are used by a default install of Ansible (other directories may be used by different modules):

Directory	Description
tasks	The tasks folder should contain a <code>main.yml</code> file, which should include a list of the tasks for this role. Any task includes that are contained in these roles will look for their files in this folder also. This allows you to split a large number of tasks into separate files, and use other features of task includes.
files	The files folder is the default location for files in the roles that are used by the copy or the script module.
templates	The templates directory is the location where the template module will automatically look for the jinja2 templates included in the roles.
handlers	The handlers folder should contain a <code>main.yml</code> file, which specifies the handlers for the roles, and any includes in that folder will also look for the files in the same location.
vars	The vars folder should contain a <code>main.yml</code> file, which contains the variables for this role.
meta	The meta folder should contain a <code>main.yml</code> file. This file can contain settings for the role, and a list of its dependencies. This feature is available only in Ansible 1.3 and above.
default	You should use the default folder if you are expecting variables to be sent to this role, and you want to make them optional. A <code>main.yml</code> file in this folder is read, to get the initial values for variables that can be overridden by variables, which are passed from the playbook calling the role. This feature is only available in Ansible 1.3 and above.

When using roles, the behavior of the copy, the template, and the script modules is slightly altered. In addition to searching for files by looking from the directory in which the playbook file is located, Ansible will also look for the files in the location of the role. For example, if you are using a role named `common`, these modules will change to the following behavior:

- The copy module will look for files in `roles/common/files`.
- The template module will first look for templates in `roles/common/templates`.
- The script module will first look for files in `roles/common/files`.
- The other modules might decide to look for their data in other folders inside `roles/common/`. The documentation for modules can be retrieved using `ansible-doc`, as was discussed in the *Module help* section of *Chapter 1, Getting Started with Ansible*.

## Role metadata

Using role metadata allows us to specify that our role depends on other roles. For example, if the application you are deploying needs to send an e-mail, your role could depend on a Postfix role. This would mean that before the application is set up and installed, Postfix will be installed and set up.

The `meta/main.yml` file will look similar to the following code:

```
---
allow_duplicates: no
dependencies:
  - apache
```

The `allow_duplicates` line is set to `no`, which is the default. If you set this to `no`, Ansible will not run a role the second time, if it is included twice with the same arguments. If you set it to `yes`, it will repeat the role even if it has run before. You can leave it off instead of setting it to `no`.

Dependencies are specified in the same format as roles. This means you can pass variables here; either static values or variables that are passed to the current role.

## Role defaults

The second feature included with Ansible 1.3 is variable default values. If you place a `main.yml` file in the `defaults` directory for the role, these variables will be read into the role; however, they can be overridden by variables in the `vars/main.yml` file, or the variables that are passed to the role when it is included. This allows you to make passing variables to the role optional. These files look exactly like other variable files. For example, if you used a variable named `port` in your role, and you want to default it to port 80, your `defaults/main.yml` file will look similar to the following code:

```
---
port: 80
```

## Speeding things up

As you add more and more machines and services to your Ansible configuration, you will find things getting slower and slower. Fortunately, there are several tricks you can use to make Ansible work on a bigger scale.

## Provisioning

Ansible isn't just limited to being able to configure our machines; we can also use it to create the machines that we will be configuring. We are also not limited to just making the machines to be configured, we can also make networks, load balancers, DNS entries, or even your whole infrastructure. You can even have this automatically happen before you provision the machine by using the `group`, `group_by` and `add_host` modules.

In the following example, we use Google Compute to create two machines, and then install and start MySQL server on them:

```
---
- name: Setup MySQL Infrastructure
  hosts: localhost
  connection: local
  tasks:
    - name: Start GCE Nodes
      gce:
        image: centos-6
        name: "mysql-{{ item }}"
        tags: mysql
        zone: us-central1-a
        with_sequence: count=2
        register: nodes
```

```
when: '"mysql-{{ item }}" not in groups.all'

- name: Wait for the nodes to start
  wait_for:
    host: "{{ item.instance_data[0].public_ip }}"
    port: 22
  with_items: nodes.results
  when: not item|skipped

- name: Register the hosts in a group
  add_host:
    name: "{{ item.instance_data[0].name }}"
    ansible_ssh_host: "{{ item.instance_data[0].public_ip }}"
    groups: "tag_mysql"
  with_items: nodes.results
  when: not item|skipped

- name: Setup MySQL
  hosts: tag_mysql
  tasks:
    - name: Install MySQL
      yum:
        name: mysql
        state: present

    - name: Start MySQL
      service:
        name: mysqld
        state: started
        enabled: yes
```

## Tags

Ansible tags are features that allow you to select the parts of a playbook that you need to run, and which should be skipped. While Ansible modules are idempotent and will automatically skip if there are no changes, this often requires a connection to the remote hosts. The yum module is often quite slow in determining whether a module is the latest, as it will need to refresh all the repositories.

If you know you don't need certain actions to be run, you can select to run only those tasks that have been tagged with a particular tag. This doesn't even try to run the tasks, it simply skips over it. This will save time on almost all the modules even if there is nothing to be done.



Let's say you have a machine that has a large number of shell accounts, but also several services set up to run on it. Now, imagine that a single user's SSH key has been compromised and needs to be removed immediately. Instead of running the entire playbook, or rewriting the playbooks to only include the steps necessary to remove that key, you could simply run the existing playbooks with the SSH keys tag, and it would only run the steps necessary to copy out the new keys, instantly skipping anything else.

This is particularly useful if you have a playbook with a playbook includes in it that covers your whole infrastructure. With this setup, you can quickly deploy security patches, change passwords, and revoke keys across your entire infrastructure as quickly as possible.

Tagging tasks is really easy; simply add a key named `tag`, and set its value to a list of the tags you want to give it. The following code shows us how to do this:

```
---
- name: Install and setup our webservers
  hosts: webservers
  tasks:
    - name: install latest software
      yum
      name: "{{ item }}"
      state: latest
      notify: restart apache
      tags:
        - patch
      with_items:
        - httpd
        - webalizer

    - name: Create subdirectories
      file
      dest: "/var/www/html/{{ item }}"
      state: directory
      mode: 755
      owner: apache
      group: apache
      tags:
        - deploy
      with_items:
        - pub

    - name: Copy in web files
      copy
```

---

```

    src: "website/{{ item }}"
    dest: "/var/www/html/{{ item }}"
    mode: 0755
    owner: apache
    group: apache
  tags:
    - deploy
  with_items:
    - index.html
    - logo.png
    - style.css
    - app.js
    - pub/index.html

- name: Copy webserver config
  tags:
    - deploy
    - config
  copy
    src: website/httpd.conf
    dest: /etc/httpd/conf/httpd.conf
    mode: 0644
    owner: root
    group: root
  notify: reload apache

- name: set apache to start on startup
  service
    name: httpd
    state: started
    enabled: yes

handlers:
- name: reload apache
  service: name=httpd state=reloaded

- name: restart apache
  service: name=httpd state=restarted

```

This play defines the patch, deploy, and config tags. If you know which operation you wish to do in advance, you can run Ansible with the correct argument, only running the operations you choose. If you don't supply a tag on the command line, the default is to run every task. For example, if you want Ansible to only run the tasks tagged as deploy, you will run the following command:

```
$ ansible-playbook webservers.yml --tags deploy
```

In addition to working on discrete tasks, tags are also available to roles, which make Ansible apply only the roles for the tags that have been supplied on the command line. You apply them similarly to the way they are applied to tasks. For example, refer to the following code:

```
---
- hosts: website1
  roles:
    - common
    - { role: apache, tags: ["patch"] }
    - { role: website2, tags: ["deploy", "patch"] }
```

In the preceding code, the `common` role does not get any tags, and will not be run if there are any tags applied. If the `patch` tag is applied, the `apache` and `website2` roles will be applied, but not `common`. If the `deploy` tag is applied; only the `website2` tag will be run. This will shorten the time required to patch servers or run deployments, as the unnecessary steps will be completely skipped.

## Ansible's pull mode

Ansible includes a pull mode that can drastically improve the scalability of your playbooks. So far we have only covered using Ansible to configure another machine over SSH. This is a contrast to Ansible's pull mode, which runs on the host that you wish to configure. Since `ansible-pull` runs on the machine that it is configuring, it doesn't need to make connections to other machines and runs much faster. In this mode, you provide your configuration in a git repository that Ansible downloads and uses to configure your machine.

You should use Ansible's pull mode in the following situations:

- Your node might not be available when configuring them, such as members of auto-scaling server farms
- You have a large amount of machines to configure and even with large values of forks, it would take a long time to configure them all
- You want machines to update their configuration automatically when the repository changes
- You want to run Ansible on a machine that may not have network access yet, such as in a kick start post install

However, the pull mode does have the following disadvantages that make it unsuitable for certain circumstances:

- To connect to other machines and gather variables, or to copy a file, you need to have credentials on the managed nodes

- You need to co-ordinate the running of the playbook across a server farm; for example, if you could only take three servers offline at a time
- The servers are behind strict firewalls that don't allow incoming SSH connections from the nodes you used to configure them for Ansible

The pull mode doesn't require anything special in your playbooks, but it does require some setup on the nodes you want configured. In some circumstances, you can do this using Ansible's normal push mode. Here is a small play to setup pull mode on a machine:

```
---
- name: Ansible Pull Mode
  hosts: pullhosts
  tasks:
    - name: Setup EPEL
      command: "rpm -ivh
        http://download.fedoraproject.org/pub/epel/6/i386/epel-
        release-6-8.noarch.rpm"
      args:
        creates=/etc/yum.repos.d/epel.repo

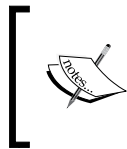
    - name: Install Ansible + Dependencies
      yum:
        name: "{{ item }}"
        state: latest
        enablerepo: epel
      with_items:
        - ansible
        - git-core

    - name: Make directory to put downloaded playbooks in
      file:
        state: directory
        path: /opt/ansiblepull

    - name: Setup cron
      cron:
        name: "ansible-pull"
        user: root
        minute: "*/5"
        state: present
        job: "ansible-pull -U
        https://git.int.example.com.com/gitrepos/ansiblepull.git
        -D /opt/ansiblepull {{ inventory_hostname_short }}.yaml"
```

In this example, we performed the following steps:

1. First we installed and set up **EPEL**. This is a repository with extra software for CentOS. Ansible is available in the EPEL repository.
2. Next we installed Ansible, making sure to enable the EPEL repository.
3. Then we created a directory for Ansible's pull mode to put the playbooks in. Keeping these files around means you don't need to download the whole git repository all the time; only updates are required.
4. Finally we set up a cron job that will try to run the `ansible-pull` mode config every five minutes.



The preceding code downloads the repository off an internal HTTPS git server. If you want to download the repository instead of SSH, you will need to add a step to install SSH keys, or generate keys and copy them to the git machine.

## Storing secrets

Eventually, you will need to include sensitive data in your Ansible recipes. All the recipes that we have discussed so far have to be stored on the disk in plain text; if you are also storing it in source control, then third parties may even have access to this data. This is risky and may be in violation of your corporate policies.

This can be avoided using Ansible vaults. Vaults are files that are encrypted and can be decrypted by Ansible transparently. You can use them for includes, variable files, tasks lists in roles and any other YAML formatted file that Ansible uses. You can also use it with both JSON and YAML files included with the `-e` command-line argument to `ansible-playbook`. Vault files are managed with the `ansible-vault` command and can be used as if they were not encrypted at all.

The `ansible-vault` command has several modes, which are given as the first argument. This table describes the modes:

Mode	Action
Create	This starts your default editor to create a new encrypted file
Encrypt	This encrypts an existing file, turning it into a vault
Edit	This edits a vault allowing you to change the content
Rekey	This changes the password that is used to encrypt the vault
Decrypt	This decrypts the vault turning it back into a regular file

For example, to create a new variable file for your staging environment you would run:

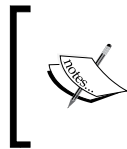
```
$ ansible-vault create vars/staging.yml
```

This command will prompt you for a password, ask you to confirm it, and then open your editor so that you can add the content; finally, the encrypted content will be saved in `vars/staging.yml`.

When using a vault file, you need to provide the password so that they can be decrypted. This can be done in one of three ways. You can give the `--ask-vault-pass` argument to Ansible, which will cause Ansible to prompt for the password every time it starts. You can also use the `--vault-password-file` argument, which points to a file containing the password. Finally, you can add `vault_password_file` to the `ansible.cfg` file to automatically make Ansible use the vault password file for every command. It is important to note that only one password can be supplied for each Ansible run, so you can't include several different files with different passwords.

In order to have Ansible prompt for a password to run a playbook that is encrypted, you will do the following:

```
$ ansible-playbook --ask-vault-pass encrypted.yml
```



The password file can also be an executable. To print to the screen print to standard error, to read from the user you can use `stdin` as usual and finally the script needs to print the password to `stdout` before it exits.

## Summary

In this chapter, we have covered the techniques required when moving from a simple setup to a larger deployment. We discussed how to separate your playbook into multiple parts using includes. We then looked at how we can package related includes and automatically include them all at once using roles. Finally, we discussed the pull mode, which allows you to automate the deployment of playbooks on the remote node itself.

In the next chapter, we will cover writing your own modules. We start this by building a simple module using bash scripting. We then look at how Ansible searches for modules, and how to make it find your own custom ones. Then, we take a look at how you can use Python to write more advanced modules using features that Ansible provides. Finally we will write a script that configures Ansible to pull its inventory from an external source.



# 5

## Custom Modules

Until now we have been working solely with the tools provided to us by Ansible. This does afford us a lot of power, and make many things possible. However if you have something particularly complex or if you find yourself using the script module a lot, you will probably want to learn how to extend Ansible.

In this chapter, you will learn the following topics:

- How to write modules in Bash scripting or Python
- Using the custom modules that you have developed
- Writing a script to use an external data source as an inventory

Often when you approach something complex in Ansible, you write a script module. The issue with script modules is that you can't process their output, or trigger handlers based on their output easily. So, although the script module works in some cases, using a module can be better.

Use a module instead of writing a script when:

- You don't want to run the script every single time
- You need to process the output
- Your script needs to make facts
- You need to send complex variables as arguments

If you want to start writing modules, you should check out the Ansible repository. If you want your module to work with a particular version, you should also switch to that version to ensure compatibility. The following commands will set you up to develop modules for Ansible 1.3.0.

```
$ git clone (https://github.com/ansible/ansible.git)
$ cd ansible
$ git checkout v1.3.0
$ chmod +x hacking/test-module
```



Checking out the Ansible code gives you access to a handy script that we will use later to test our modules. We will also make this script executable in anticipation of its use later in the chapter.

## Writing a module in Bash

Ansible allows you to write modules in any language that you prefer. Although most modules in Ansible work with JSON, you are allowed to use shortcuts if you don't have any JSON parsing facilities available. Ansible will hand you arguments in their original key value forms, if they were provided in that format. If complex arguments are provided, you will receive JSON-encoded data. You could parse this using something like `jsawk` (<https://github.com/micha/jsawk>) or `jq` (<http://stedolan.github.io/jq/>), but only if they are installed on your remote machine.

Ansible already has a module that lets you change the hostname of a system, but it only works with systemd-based systems. So let's write one that works with the standard `hostname` command. We will start just printing the current hostname and then expand the script from there. Here is what that simple module looks like:

```
#!/bin/bash

HOSTNAME="$(hostname)"

echo "hostname=${HOSTNAME}"
```

If you have written Bash scripts before, this should seem extremely basic. Essentially, what we are doing is grabbing the hostname and printing it out in a key value form. Now that we have written the first cut of the module, we should test it out.

To test the Ansible modules, we use the script that we ran the `chmod` command on earlier. This command simply runs your module, records the output, and returns it to you. It also shows how Ansible interpreted the output of the module. The command that we will use looks like the following:

```
ansible/hacking/test-module -m ./hostname
```

The output of the previous command should look like this:

```
* module boilerplate substitution not requested in module, line
numbers will be unaltered
*****
RAW OUTPUT
hostname=admin01.int.example.com

*****
```

```

PARSED OUTPUT
{
  "hostname": "admin01.int.example.com"
}

```

Ignore the notice at the top; it does not apply to modules built with bash. You can see the raw output that our script sent, which looks exactly the way we expected. The test script also gives you the parsed output. In our example, we are using the short output format and we can see here that Ansible is correctly interpreting it into the JSON that it normally accepts from modules.

Let's expand out the module to allow setting the `hostname`. We should write it so that it doesn't make any changes unless required, and lets Ansible know whether changes were made or not. This is actually pretty simple for the small command that we are writing. The new script should look something like this:

```

#!/bin/bash

set -e

# This is potentially dangerous
source ${1}

OLDHOSTNAME="$(hostname)"
CHANGED="False"

if [ ! -z "$hostname" -a "${hostname}x" != "${OLDHOSTNAME}x" ];
then
    hostname $hostname
    OLDHOSTNAME="$hostname"
    CHANGED="True"
fi

echo "hostname=${OLDHOSTNAME} changed=${CHANGED}"
exit 0

```

The previous script works as follows:

1. We set Bash's exit on error mode, so that we don't have to deal with errors from the `hostname` method. Bash will automatically exit on failure with its exit code. This will signal Ansible that something went wrong.
2. We source the argument file. This file is passed from Ansible as the first argument to the script. It contains the arguments that were sent to our module. Because we are sourcing the file, this can be used to run arbitrary commands; however, Ansible can already do this, so it's not that much of a security issue.

3. We collect the old hostname and default `CHANGED` to `False`. This allows us to see whether our module needs to perform any changes.
4. We check whether we were sent a new hostname to set, and whether that hostname is different from the one that is currently set.
5. If both these tests are true, we try to change the hostname, and set `CHANGED` to `True`.
6. Finally, we output the results and exit. This includes the current hostname and whether we made changes or not.

Changing the hostname on a Unix machine requires root privileges. So while testing this script, you need to make sure to run it as the root user. Let's test this script using `sudo` to see whether it works. This is the command you will use:

```
sudo ansible/hacking/test-module -m ./hostname
-a 'hostname=test.example.com'
```

If `test.example.com` is not the current hostname of the machine, you should get the following output:

```
* module boilerplate substitution not requested in module, line
numbers will be unaltered
*****
RAW OUTPUT
hostname=test.example.com changed=True

*****
PARSED OUTPUT
{
  "changed": true,
  "hostname": "test.example.com"
}
```

As you can see, our output is being parsed correctly, and the module claims that changes have been made to the system. You can check this yourself with the `hostname` command. Now, run the module for the second time with the same hostname. You should see an output that looks like this:

```
* module boilerplate substitution not requested in module, line
numbers will be unaltered
*****
RAW OUTPUT
hostname=test.example.com changed=False

*****
```

```
PARSED OUTPUT
{
  "changed": false,
  "hostname": "test.example.com"
}
```

Again, we see that the output was parsed correctly. This time, however, the module claims to not have made any changes, which is what we expect. You can also check this with the `hostname` command.

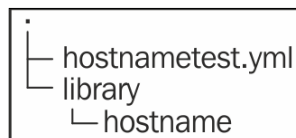
## Using a custom module

Now that we have written our very first module for Ansible, we should give it a go in a playbook. Ansible looks at several places for its modules—first it looks at the place specified in the `library` key in its config file (`/etc/ansible/ansible.cfg`), next it will look at the location specified using the `--module-path` argument in the command line, then it will look in the same directory as the playbook for a `library` directory containing modules, and finally it will look in the `library` directory for any roles that may be set.

Let's create a playbook that uses our new module and place it in a `library` directory in the same place so that we can see it in action. Here is a playbook that uses the `hostname` module:

```
---
- name: Test the hostname file
  hosts: testmachine
  tasks:
    - name: Set the hostname
      hostname: hostname=testmachine.example.com
```

Then create a directory named `library` in the same directory as the playbook file. Place the `hostname` module inside the library. Your directory layout should look like this:



Now when you run the playbook, it will find the `hostname` module in the `library` directory and execute it. You should see an output like this:

```
PLAY [Test the hostname file] *****

GATHERING FACTS *****
ok: [ansibletest]

TASK: [Set the hostname] *****
changed: [ansibletest]

PLAY RECAP *****
ansibletest      : ok=2    changed=1    unreachable=0
failed=0
```

Running it again should change the result from `changed` to `ok`. Congratulations! You have now created and executed your very first module. This module is very simple right now, but you can extend it to know about the `hostname` file, or other methods to configure the `hostname` at boot time.

## Writing modules in Python

All of the modules that are distributed with Ansible are written in Python. Because Ansible is also written in Python, these modules can directly integrate with Ansible. Here are a few reasons why you should write modules in Python:

- Modules written in Python can use boilerplate, which reduces the amount of code required
- Python modules can provide documentation to be used by Ansible
- Arguments to your module are handled automatically
- Output is automatically converted to JSON for you
- Ansible upstream only accepts plugins using Python with the boilerplate code included

You can still build Python modules without this integration by parsing the arguments and outputting JSON yourself. However, with all the things you get for free, it would be hard to make a case for it.

Let's build a Python module that lets us change the currently running init level of the system. There is a Python module named `pyutmp` that will let us parse the `utmp` file. Unfortunately, since Ansible modules have to be contained in a single file, we can't use it unless we know it will be installed on the remote systems, so we will resort to using the `runlevel` command and parsing its output. Setting the run level can be done with the `init` command.

The first step is to figure out what arguments and features the module supports. For the sake of simplicity, let's have our module only accept one argument. We'll use the argument `runlevel` to get the run level the user wants to change to. To do this, we will instantiate the `AnsibleModule` class with our data as follows:

```
module = AnsibleModule(
    argument_spec = dict(
        runlevel=dict(default=None, type='str')
    )
)
```

Now we need to implement the actual guts of the module. The module object that we created previously provides us with a few shortcuts. There are three shortcuts that we will be using in the next step. As there are way too many methods to document here, you can see the whole `AnsibleModule` class and all the available helper functions in `lib/ansible/module_common.py`.

- `run_command`: This method is used to launch external commands and retrieve the return code, the output from `stdout`, and also the output from `stderr`.
- `exit_json`: This method is used to return data to Ansible when the module has completed successfully.
- `fail_json`: This method is used to signal a failure to Ansible, with an error message and return code.

The following code actually manages the init level of the system comments to explain what it does:

```
def main():          #1
    module = AnsibleModule(      #2
        argument_spec = dict(    #3
            runlevel=dict(default=None, type='str')      #4
        )          #5
    )          #6

    # Ansible helps us run commands      #7
    rc, out, err = module.run_command('/sbin/runlevel')      #8
    if rc != 0:          #9
        module.fail_json(msg="Could not determine current runlevel.",
            rc=rc, err=err)      #10

    # Get the runlevel, exit if its not what we expect      #11
    last_runlevel, cur_runlevel = out.split(' ', 1)      #12
    cur_runlevel = cur_runlevel.rstrip()      #13
    if len(cur_runlevel) > 1:      #14
```

```
    module.fail_json(msg="Got unexpected output from runlevel.",
                    rc=rc)          #15

    # Do we need to change anything      #16
    if module.params['runlevel'] is None or
        module.params['runlevel'] == cur_runlevel:      #17
        module.exit_json(changed=False, runlevel=cur_runlevel)    #18

    # Check if we are root      #19
    uid = os.geteuid()          #20
    if uid != 0:                #21
        module.fail_json(msg="You need to be root to change the
                               runlevel")                #22

    # Attempt to change the runlevel      #23
    rc, out, err = module.run_command('/sbin/init %s' %
        module.params['runlevel'])      #24
    if rc != 0:                  #25
        module.fail_json(msg="Could not change runlevel.", rc=rc,
                               err=err)      #26

    # Tell ansible the results      #27
    module.exit_json(changed=True, runlevel=cur_runlevel)    #28
```

There is one final thing to add to the boilerplate to let Ansible know that it needs to dynamically add the integration code into our module. This is the magic that lets us use the `AnsibleModule` class and enables our tight integration with Ansible. The boilerplate code needs to be placed right at the bottom of the file, with no code afterwards. The code to do this looks like this:

```
# include magic from lib/ansible/module_common.py
#<<INCLUDE_ANSIBLE_MODULE_COMMON>>
main()

So, finally, we have the code for our module built. Putting it all
together, it should look like the following code:
#!/usr/bin/python      #1
# -*- coding: utf-8 -*-      #2

import os      #3

def main():          #4
    module = AnsibleModule(      #5
        argument_spec = dict(      #6
            runlevel=dict(default=None, type='str'),      #7
        ),      #8
```

---

```

)          #9

# Ansible helps us run commands          #10
rc, out, err = module.run_command('/sbin/runlevel')      #11
if rc != 0:      #12
    module.fail_json(msg="Could not determine current runlevel.",
        rc=rc, err=err)      #13

# Get the runlevel, exit if its not what we expect      #14
last_runlevel, cur_runlevel = out.split(' ', 1)      #15
cur_runlevel = cur_runlevel.rstrip()      #16
if len(cur_runlevel) > 1:      #17
    module.fail_json(msg="Got unexpected output from runlevel.",
        rc=rc)      #18

# Do we need to change anything      #19
if (module.params['runlevel'] is None or
    module.params['runlevel'] == cur_runlevel):      #20
    module.exit_json(changed=False, runlevel=cur_runlevel)      #21

# Check if we are root      #22
uid = os.geteuid()      #23
if uid != 0:      #24
    module.fail_json(msg="You need to be root to change the
        runlevel")      #25

# Attempt to change the runlevel      #26
rc, out, err = module.run_command('/sbin/init %s' %
    module.params['runlevel'])      #27
if rc != 0:      #28
    module.fail_json(msg="Could not change runlevel.", rc=rc,
        err=err)      #29

# Tell ansible the results      #30
module.exit_json(changed=True, runlevel=cur_runlevel)      #31

# include magic from lib/ansible/module_common.py      #32
#<<INCLUDE_ANSIBLE_MODULE_COMMON>>      #33
main()      #34

```



You can test this module the same way you tested the Bash module with the `test-module` script. However, you need to be careful, because if you run it with `sudo`, you might reboot your machine or alter the init level to something you don't want. This module is probably better tested by using Ansible itself on a remote test machine. We follow the same process as described in the *Writing a module in Bash* section earlier in this chapter. We create a playbook that uses the module, and then place the module in a library directory that has been made in the same directory as the playbook. Here is the playbook we need to use:

```
---
- name: Test the new init module
  hosts: testmachine
  user: root
  tasks:
    - name: Set the init level to 5
      init: runlevel=5
```

Now you should be able to try and run this on a remote machine. The first time you run it, if the machine is not already in run level 5, you should see it change the run level. Then you should be able to run it for a second time to see that nothing has changed. You might also want to check to make sure the module fails correctly when not run as root.

## External inventories

In *Chapter 1, Getting Started with Ansible*, we saw how Ansible needs an inventory file, so that it knows where its hosts are and how to access them. Ansible also allows you to specify a script that allows you to fetch the inventory from another source. External inventory scripts can be written in any language that you like as long as they output valid JSON.

An external inventory script has to accept two different calls from Ansible. If called with `-list`, it must return a list of all the available groups and hosts. Additionally, it may be called with `--host`. In this case, the second argument will be a hostname and the script is expected to return a list of variables for that host. All the outputs are expected in JSON, so you should use a language that supports it naturally.

Let's write a module that takes a CSV file listing all your machines and presents this to Ansible as an inventory. This will be handy if you have a **Configuration Management Database (CMDB)** that allows you to export your machine list as CSV, or for someone who keeps records of their machines in a spreadsheet. Additionally, it doesn't require any dependencies outside Python, as a CSV processing module is already included with Python. This really just parses the CSV file into the right data structures and prints them out as JSON data structures. The following is an example CSV file we wish to process; you may wish to customize it for the machines in your environment:

```
Group,Host,Variables
test,example,ansible_ssh_user=root
test,localhost,connection=local
```

This file needs to be converted into two different JSON outputs. When `--list` is called, we need to output the whole thing in a form that looks like this:

```
{"test": ["example", "localhost"]}
```

And when it is called with the arguments `--host example`, it should return this:

```
{"ansible_ssh_user": "root"}
```

Here is the script that opens a file named `machines.csv` and produces the dictionary of the groups if `--list` is given: Additionally, when `--host` and a hostname are given, it parses that host's variables and returns them as a dictionary. The script is well-commented, so you can see what it is doing. You can run the script manually with the `--list` and `--host` arguments to confirm that it behaves correctly.

```
#!/usr/bin/env python
# -*- coding: utf-8 -*-

import sys
import csv
import json

def getlist(csvfile):
    # Init local variables
    glist = dict()
    rowcount = 0

    # Iterate over all the rows
    for row in csvfile:
        # Throw away the header (Row 0)
        if rowcount != 0:
            # Get the values out of the row
            (group, host, variables) = row
```

```
        # If this is the first time we've
        # read this group create an empty
        # list for it
        if group not in glist:
            glist[group] = list()

        # Add the host to the list
        glist[group].append(host)

    # Count the rows we've processed
    rowcount += 1

    return glist

def gethost(csvfile, host):
    # Init local variables
    rowcount = 0

    # Iterate over all the rows
    for row in csvfile:
        # Throw away the header (Row 0)
        if rowcount != 0 and row[1] == host:
            # Get the values out of the row
            variables = dict()
            for kvpair in row[2].split():
                key, value = kvpair.split('=', 1)
                variables[key] = value

            return variables

    # Count the rows we've processed
    rowcount += 1

command = sys.argv[1]

#Open the CSV and start parsing it
with open('machines.csv', 'r') as infile:
    result = dict()
    csvfile = csv.reader(infile)

    if command == '--list':
        result = getlist(csvfile)
    elif command == '--host':
        result = gethost(csvfile, sys.argv[2])

    print json.dumps(result)
```

You can now use this inventory script to provide the inventory when using Ansible. A quick way to test that everything is working correctly is to use the `ping` module to test the connection to all the machines. This command will not test whether the hosts are in the right groups; if you want to do that, you can use the same `ping` module command but instead of running it across all, you can simply use the group you would like to test. If your inventory file is executable, then Ansible will run it and use the output. You can also use a directory and Ansible will include all files inside, running them if they are executable.

```
$ ansible -i csvinventory -list-hosts -m ping all
```

Similar to when you used the `ping` module in *Chapter 1, Getting Started with Ansible*, you should see an output that looks like the following:

```
localhost | success >> {
  "changed": false,
  "ping": "pong"
}

example | success >> {
  "changed": false,
  "ping": "pong"
}
```

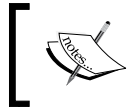
This indicates that you can connect and use Ansible on all the hosts from your inventory. You can use the same `-i` argument with `ansible-playbook` to run your playbooks with the same inventory.

## Extending Ansible

Apart from writing modules and external inventory script, you can also extend the core functionality of Ansible itself. This allows you to include even more functionality into Ansible using Python. By writing plugins for Ansible, you can do the following:

- Add new methods for controlling other machines with connection plugins
- Use data from external sources outside Ansible in loops or lookups with lookup plugins
- Add new filters for use with variables or in templates with filter plugins
- Include callbacks that run when certain actions happen inside Ansible with callback plugins

To add extra plugins to your Ansible projects, we create a Python file in the plugin directories specified in your `ansible.cfg` file. Alternatively, we can add new directories containing our plugins to the list of directories already present.



Do not remove any of the existing directories, as you will be removing plugins that provide core Ansible features such as the ones we have mentioned earlier in this book.

When writing plugins to Ansible, you should focus on making them flexible and reusable where possible. This way you end up removing some complexity from your playbooks and templates into a few complex Python files. Focusing on reusability of your plugins also means it is possible to submit them back to the Ansible project using a GitHub pull request. If you submit your plugins back to Ansible, then everybody will be able to take advantage of your plugin, and you would have played a part in the development of Ansible itself. More information on contributing to Ansible can be found in the `CONTRIBUTORS.md` file in the Ansible source code.

## Connection plugins

Connection plugins are responsible for relaying files to and from the remote machine, and executing modules. You will no doubt have already used the SSH, local and possibly the winrm plugins with the playbooks used earlier in the book.

Apart from the normal `__init__()` method, connection plugins must implement the following methods:

Method	Purpose
<code>connect()</code>	This opens the connection to the host we are managing
<code>exec_command()</code>	This executes a command on the managed host
<code>put_file()</code>	This copies a file to the managed host
<code>fetch_file()</code>	This downloads a file from the managed host
<code>close()</code>	This closes the connection to the host we are managing

## Lookup plugins

Lookup plugins are used in two ways: to include data from outside as a `lookup()`, or in the `with_` style to loop over items. You can even combine the two to loop over external data as is done in the `with_fileglob` lookup plugin. Several lookup plugins have been demonstrated earlier in the book, particularly in *Looping* section of *Chapter 3, Advanced Playbook*.

Lookup plugins are simple to write, and apart from the normal `__init__()` method, they only need you to implement a `run()` method. This method uses the `listify_lookup_plugin_terms()` method from the Ansible `utils` package to gather the arguments list passed to it, and returns the result. As an example, we will now demonstrate a lookup plugin to read data from a JSON encoded file:

```
import json

class LookupModule(object):
    def __init__(self, basedir=None, **kwargs):
        pass

    def run(self, terms, inject=None, **kwargs):
        with open(terms, 'r') as f:
            json_obj = json.load(f)

        return json_obj
```

This can be used either as a lookup plugin to fetch complex data or, if the file contains a JSON list, as a loop using `with_jsonfile`. Save the preceding example as `jsonfile.py` in one of your lookup plugin directories. You can see that we have declared a new class named `LookupModule`; this is what Ansible tries to find within your Python file, so you must use this name. We then create a constructor (named `__init__`) so that Ansible can create our class. Finally, we make a small method that simply opens a JSON file, parses it and returns the result to Ansible.

We should note that this example is really simplified and only looks in the current working directory for the file. It could be extended later to look in a roles file directory or elsewhere in order to better conform to conventions set by other Ansible modules.

You can then use this lookup plugin in a playbook like this:

```
- name: Print the JSON data we received
  debug:
    msg: "{{ lookup('json', 'file.json') }}"
```

## Filter plugins

Filter plugins are extensions to the Jinja2 template engine that Ansible uses to process variables and generate files from templates. These extensions can be used in playbooks to perform data processing on variables, or they can be used inside templates to process data before it is included in the file. They simplify the processing of data by moving the complexity to a Python file and away from the templates or Ansible configuration.

Filter plugins are a little different from other plugins. To implement one, you first write a simple function that simply takes the input you need and returns the result. Second, you create a class named `FilterModule`, and implement a `filters` method on it, which returns a Python dictionary, where the keys are the filter names and the values the functions to call.

Here is a sample implementation of a plugin that can be used to calculate the minimum number of servers required in any group to avoid a split-brain situation: This number in most systems is one greater than 50% of the nodes available.

```
def quorum(list_of_machines):

    n = len(list_of_machines)
    quorum = n / 2 + 1

    return quorum

class FilterModule(object):
    def filters(self):
        return {
            'quorum': quorum,
        }
```

Simply put, this module counts how many items were in the list passed to it, divides it by two, and then adds one. It is all done as integer math, so remainders are ignored and everything is done as whole numbers, which suits our purpose.

This filter can then be used in a playbook or a template. For example, if we wanted to configure an Elasticsearch cluster to have a quorum and avoid split-brain issues, we will use the following line of code:

```
discovery.zen.minimum_master_nodes: {{ play_hosts|quorum }}
```

This will get the list of hosts this play is being run on (from the `play_hosts` variable), and then calculate how many of those are required to obtain a quorum.

## Callback plugins

Callback plugins are used to provide information about actions that are happening in Ansible to external systems. They are automatically activated if they are found in the directories specified under the `callback_plugins` directory into Ansible configuration. They are often useful when playbooks are being run as automated tasks as they can give feedback via other channels than the standard output. Callback plugins have a wide variety of uses, as follows:

- Sending an e-mail at the end of a playbook with the statistics of what changed
- Recording a running log of changes being made to `syslog`
- Notifying a chat channel when a playbook task fails
- Updating a CMDB as changes are made to ensure an accurate view of the configuration of every system
- Alerting an admin when a play has exited early because all hosts have failed

The callback plugins are the most complicated plugins to write because they have the ability to hook into most of Ansible's features. Just because there are many options though does not mean you need to implement them all. You only need to implement the ones your callback will use. Here is a list of the methods you can implement, along with their description:

- `def on_any(self, *args, **kwargs):` This is called before any of the other callbacks are called. Because the arguments differ from callback to callback, it expands its arguments into `args` and `kwargs`. This method is good for logging. Using it for anything else can become quite complicated.
- `runner_on_failed(self, host, res, ignore_errors=False):` This is run after a task fails. The `host` argument contains the host on which the task was running, `res` contains the task data from the playbook and anything that was returned, and `ignore_errors` contains a boolean value specifying whether the playbook indicated errors should be ignored.
- `runner_on_ok(self, host, res):` This runs after a task succeeds or when a poll for an async job succeeds. The argument `host` contains the host on which the task was running and `res` contains the task data from the playbook and any data that was returned.
- `runner_on_skipped(self, host, item=None):` This runs after a task is skipped. The argument `host` contains the host on which the task would have run if it were not skipped and the `item` argument contains the loop item, which is currently being iterated over.



- `runner_on_unreachable(self, host, res)`: This runs when a host is found to be unreachable. The `host` argument contains the unreachable host and `res` contains the error message from the connection plugin.
- `runner_on_no_hosts(self)`: This callback runs when a task is started without any hosts. It does not have any variables.
- `runner_on_async_poll(self, host, res, jid, clock)`: This runs whenever an async job is polled for status. The variable `host` contains the host that is being polled, `res` contains details of the polling, `jid` contains the job ID, and `clock` contains the amount of time remaining before the job fails.
- `runner_on_async_ok(self, host, res, jid)`: This runs when polling has completed without an error. The argument `host` contains the host that was being polled, `res` holds the results from the task, and `jid` contains the job ID.
- `runner_on_async_failed(self, host, res, jid)`: This runs when polling has completed with an error. The argument `host` contains the host that was being polled, `res` holds the results from the task, and `jid` contains the job ID.
- `playbook_on_start(self)`: This callback is executed when a playbook is started with `ansible-playbook`. It does not use any variables.
- `playbook_on_notify(self, host, handler)`: This callback is run whenever a handler is notified. Because this is run when the notify happens and not when the handler runs, it may run multiple times for each handler. It has two variables: `host` stores the hostname on which the task notified and `handler` stores the name of the handler that was notified.
- `playbook_on_no_hosts_matched(self)`: This callback runs if a play starts that does not match any host. It does not have any variables.
- `playbook_on_no_hosts_remaining(self)`: This callback runs when all the hosts in a play have errors and the play is unable to continue.
- `playbook_on_task_start(self, name, is_conditional)`: This callback runs right before each task, even if the task is going to be skipped. The `name` variable is set to the name of the task, and `is_conditional` is set to the outcome of the `when` clause — `True` if the task will run, and `False` if not.
- `playbook_on_setup(self)`: This callback is executed right before the `setup` module executes across the hosts. It runs once no matter how many hosts are included. It does not include any variables.
- `playbook_on_play_start(self, name)`: This callback runs at the beginning of each play. The `name` variable contains the name of the play that is starting.
- `playbook_on_stats(self, stats)`: This callback runs at the end of a playbook right before the stats are to be printed. The `stats` variable contains the details of the playbook.

## Summary

Having read this chapter, you should now be able to build modules using either Bash or any other languages that you know. You should be able to install modules that you have either obtained from the Internet, or written yourself. We also covered how to write modules more efficiently using the boilerplate code in Python, and we wrote an inventory script that allows you to pull your inventory from an external source. Finally we covered adding new features to Ansible itself by writing connection, lookup, filter, and callback plugins.

We have tried to cover most of the things you will need when getting to know Ansible, but we can't possibly cover everything. If you would like to continue learning about Ansible, you can visit the official Ansible documentation at <http://docs.ansible.com/>.

The Ansible project is currently working on a rewrite, which will eventually be released as version 2.0. This book should stay compatible with this version and others going forward, but there will be new features that are not covered here. In version 2.0 of Ansible, you can expect the following features, which may change in the future (as it has not yet been released):

- The ability to recover from failures within a playbook
- Allowing you to run lots of tasks in parallel
- Compatibility with Python 3
- Easier debugging as errors will contain line numbers



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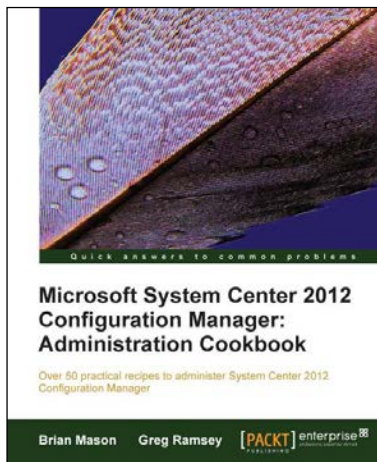
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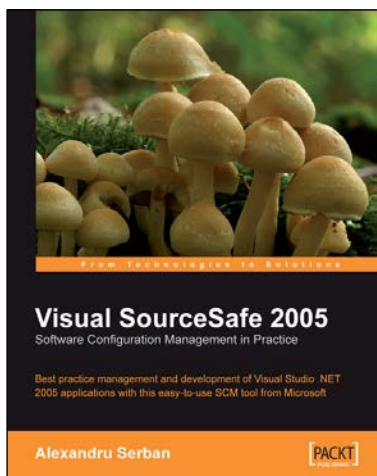


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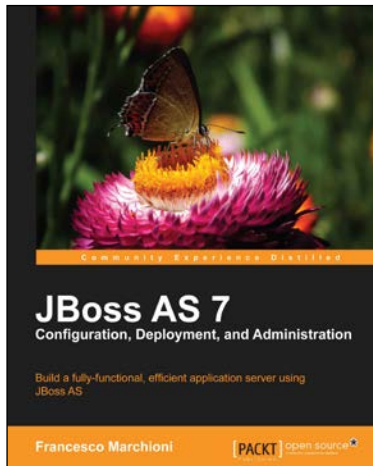
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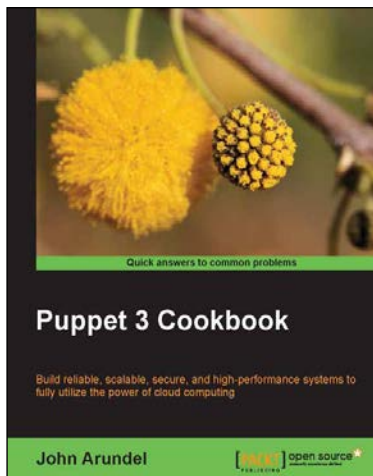
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